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Railway Engineering Under Difficulties.

THE NORTHERN RAILWAY OF CAMEROON.—[See page 84.]

Some Alloys Suitable for Instrument Work—I*

A Neglected Field for Investigation

By W. Rosenhain

THE metals used in the construction of instruments do not appear to have received the amount of careful attention which they deserve. The majority of instrument makers content themselves with using any miscellaneous brass tubing or casting that may be available, while here and there an effort may be made to lighten instruments by the use of aluminium or some little understood aluminium alloy. There seems to be no doubt that a careful study of the materials available and of their properties, with a careful mutual adaptation of the materials and design, would lead to considerable improvement in our instruments. The purposes served by different instruments, and even by different parts of the same instrument, vary so widely that the materials to be employed for them should be varied in a corresponding manner.

The wide variations of purpose, which have just been referred to, make it impossible to lay down any general specification of the requirements which should be met by metals or alloys intended for instrument work, but there are certain properties which are obviously desirable, and these may briefly be referred to. We have first of all strength and stiffness. It is true that in a good many cases the stresses which in some parts of an instrument are so slight that the thinnest sections which it is possible to employ are of ample strength, even when the metals themselves are comparatively weak, but in other cases the requirements, as regards strength and rigidity, are much more serious, and in these cases it becomes desirable to study the tensile strength and elastic modulus of the materials to be employed. As regards elastic modulus, which governs the stiffness of a given section of material, it must be remembered that steel stands far higher than any non-ferrous alloys yet discovered, in fact the strongest of the aluminium bronzes, whose strength exceeds that of the softer kinds of steel, have an elastic modulus rather less than one half that of steel, while the light alloys of aluminium have a modulus not much more than one third that of steel. On the other hand, it is to be remembered that for *equal weight* the stiffness of sections made of certain light alloys may be greater than that of steel.

The second universal requirement for the materials for instrument making is that it should be possible to work them either hot or cold, and that they should be capable of being machined and, in some cases, of being polished. Where alloys are required only in the form of castings it may be permissible to use a material which would be too hard and brittle to allow of rolling into rods or drawing into tubes, while for polishing purposes, again, the harder metals are preferable. The property of being easily machined, particularly at high speeds and with good finish, is, however, a peculiar one and must be ascertained specially for each alloy.

The durability of the materials is also of considerable importance. In this connection we have to consider first of all what might be termed "intrinsic durability," i. e. whether the metal is free from internal sources of disruption. Such internal sources of disruption may be of several kinds; they may be due to the composition and constitution of the alloy. Some alloys are known, although they are never intentionally used, which undergo spontaneous disintegration in some cases in a few hours, and in other cases after a period of years. Apart from experiments, however, on materials which have been insufficiently studied the risk of encountering this class of phenomenon is negligible. On the other hand, the treatment which is applied to some alloys is such as to leave within them the seeds of subsequent disintegration. Thus excessively hard-drawn wire or rod, and particularly thin stampings which have undergone very severe local deformation without adequate annealing are liable to undergo what is known as "season cracking." This phenomenon appears to be due to the fact that the severely distorted crystals of such a metal tend to rearrange themselves in more stable forms. This is what normally occurs when metal is softened by heating it (annealing), but when the cold work has been very severe a gradual rearrangement may occur even at the ordinary temperature, and as such rearrangement is generally accompanied by a small change in volume, splitting or cracking may result. This is one reason why it is in itself undesirable to use metals whose strength has been artificially raised by such processes. To a certain extent such treatment is, of course, permissible, and in some cases even desirable; but it is often carried too far, and this practice may be ascribed to the fact that material itself is inherently too weak properly to serve the purpose required. It would be preferable to use an inherently stronger alloy rather than to rely upon mechanical hardening.

Apart from these internal causes of possible disruption the materials of instruments depend for their durability also upon the power of resisting external causes of deterioration. Such external causes are principally mechanical wear and corrosion. Mechanical wear is, of course, confined to those parts of the instrument where movement occurs, but where these movements are of a delicate kind, and a prolonged maintenance of adjustment is necessary, resistance to wear becomes an extremely important property. There can be no doubt that for this purpose many of the alloys ordinarily used are decidedly unsuitable. A soft brass, chosen because of the ease with which it can be machined and polished, is far too soft for making the slides and the rack and pinion gears of a microscope, and similar considerations apply in many other cases.

As regards corrosion, in the majority of instruments, and particularly those which are used indoors or in otherwise protected situations, very little difficulty need arise. The majority of alloys can be adequately protected by a good lacquer, and where lacquer is insufficient, paint, enamel, or other protective coatings can be used. On the other hand, where instruments are exposed to severe conditions, such as the spray of sea-water, wind and weather—and, still worse, the fumes of many chemical and industrial operations—deterioration by corrosion becomes a very serious matter. It must, however, be admitted at once that there are no known metals other than the noble metals which can successfully resist the severest of these influences. As regards sea-water, the use of some of the alloys mentioned below if conducted in a rational manner would probably prove distinctly beneficial. In such cases, however, it is necessary so to design the instrument that no electrolytic action can be set up between different parts, and for that purpose it is necessary that all metallic materials should consist of the same alloy. Even the juxtaposition of a drawn tube and a casting of the same material will give rise to slight galvanic effects, although these are much smaller than the electric currents which are generated by the juxtaposition in contact with sea-water of two alloys of different composition. It should be remarked that in this respect exposure to sea air and spray is rather more severe than actual exposure to sea-water.

In the more severe cases which occur with instruments intended for use in works and in chemical laboratories the avoidance of corrosion could only be effected by rigorously covering all metallic parts with carefully applied and adequately thick layers of protective material. The proper choice of these coatings is a matter requiring considerable care, but it lies outside the scope of the present paper. It must be emphasized, however, that in such instruments if real utility is aimed at the whole idea of "prettiness" must be abandoned, there must be no display of bright metal at all, and in many cases it will be eminently desirable if all the metallic parts of the instrument are inclosed in an air-tight box with wood or ebonite handles protruding, while the indicating dial of the instrument is observed through a glass window. The prejudice against instruments which is still widespread in industrial circles is largely based on the idea that they are "delicate," and that they will not stand the usage of industrial life. As a matter of fact the cause of failure or derangement is in most cases due to corrosion rather than to mechanical breakage.

A further property of metals which is important from many points of view in instrument making is

TABLE I

Mechanical Properties of Alloys of Copper with Aluminium (containing up to 10% of Aluminium)

Reference Number.	Composition, per cent. Copper	Aluminium	Manganese	Condition	Strength Yield Point (Tons per square inch)	Strength Breaking Stress (Tons per square inch)	Ductility Elongation per cent. on 2 inches.
VIII. 7.	94·24%	5·76%	—	Sand Casting	4·8	17·8	67·0
,,	,,	,,	—	Chill Casting	6·0	18·8	61·0
,,	,,	,,	—	Rolled Bar	11·8	28·4	74·2
VIII. 8.	93·27%	6·73%	—	Sand Casting	4·8	18·65	—
,,	,,	,,	—	Chill Casting	—	19·96	69·0
,,	,,	,,	—	Rolled Bar	10·4	28·85	71·0
VIII. 9.	92·65%	7·35%	—	Sand Casting	6·6	21·3	71·0
,,	,,	,,	—	Chill Casting	—	21·58	84·0
,,	,,	,,	—	Rolled Bar	10·6	29·68	72·5
,,	,,	,,	—	Cold-drawn Bar	24·6	31·42	48·0
VIII. 11.	91·33%	8·67%	—	Sand Casting	9·8	28·1	48·0
,,	,,	,,	—	Chill Casting	—	30·8	55·0
,,	,,	,,	—	Rolled Bar	11·1	36·7	38·0
VIII. 12.	90·62%	9·38%	—	Sand Casting	9·7	30·38	36·25
,,	,,	,,	—	Chill Casting	10·5	33·98	43·50
,,	,,	,,	—	Rolled Bar	17·7	38·00	34·00
,,	,,	,,	—	Cold-drawn Bar	29·0	38·83	32·00
VIII. 13.	90·10%	9·90%	—	Sand Casting	11·3	31·70	21·7
,,	,,	,,	—	Chill Casting	12·4	36·93	30·5
,,	,,	,,	—	Rolled Bar	14·8	38·10	28·8
,,	,,	,,	—	Cold-drawn Bar	40·4	43·94	13·0
IX. 2.	89·06%	10·02%	0·92%	Sand Casting	14·00	35·76	22·5
,,	,,	,,	—	Chill Casting	16·00	39·90	25·0
,,	,,	,,	—	Rolled Bar	23·04	42·84	22·5
,,	,,	,,	—	Cold-drawn Bar	42·00	50·04	16·0
IX. 3.	88·00%	9·99%	2·01%	Sand Casting	13·20	34·44	24·0
,,	,,	,,	,,	Chill Casting	16·80	37·00	25·0
,,	,,	,,	,,	Rolled Bar	21·40	40·72	29·0
,,	,,	,,	,,	Cold-drawn Bar	40·88	52·08	10·0
IX. 6.	88·11%	8·91%	2·98%	Sand Casting	10·80	31·60	24·0
,,	,,	,,	,,	Chill Casting	14·80	34·40	26·0
,,	,,	,,	,,	Rolled Bar	20·00	40·00	39·0
,,	,,	,,	,,	Cold-drawn Bar	38·92	44·00	22·0

* Paper read at the recent Optical Convention.

their weight. The demand for lightness is in certain cases imperative, while in many cases a reduction in weight would be very desirable. In view of this fact, it is rather surprising to find that the use of aluminium and its alloys is not far more widespread among instrument makers than it appears to be. Some of the causes which may have retarded the use of light metals will be discussed below.

It is not the purpose of the present paper to discuss in detail the properties of the materials most commonly used in instrument making, namely, brass and gun-metal. Anything like a full discussion of these two groups of alloys would in itself form subject matter for several papers longer than the present one. In the present instance, however, the author merely desires to draw the attention of instrument makers to the fact that certain groups of alloys not ordinarily employed by them have recently received very careful and thorough investigation, and that some of them appear to possess properties which would render them of special value and interest for certain purposes in instrument making. For a full account of these alloys and for the investigations which have been carried out upon them, reference must be made to the eighth, ninth, and tenth reports of the Alloys Research Committee of the Institution of Mechanical Engineers.[1] It will be found, however, that these reports, written chiefly from the point of view of the metallurgist and engineer, and covering in all some 785 pages of the *Proceedings* of the Institution of Mechanical Engineers, present a rather formidable front to the instrument maker in search of information, and for that purpose the author has thought it desirable to abstract from those reports data concerning a few materials which appear to be of interest in the present connection.

The first group of alloys to be considered may be described as belonging to the class of bronze, that is to say, they are heavy alloys of considerable strength. Their properties so far as strength and ductility are concerned are summarized in Table I. In the first column of this table are given the reference numbers of the alloys. The roman numerals refer to the alloys research report, in which they are described, the other number being that by which each alloy is identified in the report which deals with it. By means of these numbers those interested can readily refer back to the original reports for fuller details concerning any of these alloys. The second column gives the percentage composition of the alloys, impurities being neglected.

The first six alloys of the table consist of copper and aluminium alone, while the last three also contain from 1 to 3 per cent of manganese. In the next column of the table is stated the condition in which the alloy has been tested. The term "Rolled Bar" refers to material which has been hot-rolled to a diameter of 13/16 inch or 7/8 inch, starting from a billet 3 inches in diameter, while the material described as "Cold-drawn Bar" has been drawn cold from 1¼-inch diameter down to 13/16 inch or 7/8 inch diameter.

On examining the figures in the table it will be seen that as regards sand castings alloy, No. IX 2, attains a strength of over 35 tons per square inch, while in the chill castings the same alloy attains 39.9 tons, both these figures being accompanied by an elongation of well over 20 per cent. If greater ductility is required alloy No. VIII 12 provides a sand casting with a tensile strength of just over 30 tons, and 36 per cent elongation, while such an alloy as No. VIII 9 will furnish a sand casting with a tensile strength well over 20 tons per square inch and an elongation exceeding 70 per cent. With these figures we may compare the data for ordinary brass in which the tensile strength of sand castings never exceeds 19 tons per square inch, and this figure is very rarely attained in commercial brass. In the form of castings, therefore, the alloys shown in Table I present possibilities of strength far in excess of anything that can be obtained in brass, but it must be admitted that for this very purpose they present some special difficulties. If the attempt were made to melt and cast them, by the methods usually employed in brass founding, failure would result, owing to the fact that, when molten, these alloys are considerably more sluggish than brass, and their contraction in freezing is decidedly larger. Owing to these difficulties it is sometimes stated that it is impossible to obtain satisfactory castings of these alloys, but this statement is incorrect, as the author has found that a little care and some experience of the peculiarities of these metals makes it quite possible to obtain perfectly sound results—at all events in castings of moderate size; although the cost is somewhat increased by the necessity of using comparatively large "gates."

In the form of rolled bar it will be seen that these alloys attain a tensile strength of over 40 tons, coupled in the case of alloy No. IX 6 with an elongation of 39 per cent. In this form also the strength attained is far greater than anything reached by brass, and there is no difficulty in hot-rolling any of these alloys.

In the form of cold-drawn bars the alloy No. IX 3 attains the astonishing strength of 52 tons per square inch, while still showing an elongation of 10 per cent. It will, of course, be understood that a material of these properties cannot be drawn and handled in the same manner as the weaker and softer brasses, but the author's experience with these alloys suggests that there is no insurmountable difficulty in producing from them tubes and other sections that may be required.

Apart from the mere question of tensile strength and ductility these alloys present certain interesting features. In the first place it is important to note that those containing manganese, i. e. the last three in the table, are very readily machined, working as easily and yielding as good a finish as ordinary brass to which lead has been added for the purpose of facilitating machining. An exception in this respect must, however, be made for the cold-drawn material which does not machine so readily.

Perhaps the most important feature of these alloys from the point of view of the instrument maker is their very considerable resistance to abrasion. Abrasion tests on the last three alloys described in Table I have been made by subjecting disks of the alloys 1 inch in diameter, and ¼ inch thick to rolling abrasion in contact with a hardened steel roller 2¾ inches in diameter under a load of 789 pounds. After 107,000 revolutions the weight of material removed was found to be:

Alloy IX 2, 11.6 milligrammes.
Alloy IX 3, 13.0 "
Alloy IX 6, 10.0 "

For comparison similar tests were made on disks of rail and tool steels, and the results obtained were:

Rail steel, 64.5 milligrammes.
Tool steel, 27.4 "

Taken in conjunction with the ductility of the alloys these results certainly indicate remarkable and valuable properties. Advantage has, indeed, already been taken of these properties for instrumental purposes. In a measuring machine, designed by Col. R. E. Crompton, C.B., two small steel balls were at first employed for the purpose of making contacts, but it was found that owing to the magnetic property of the steel the balls acquired small "whiskers" of magnetic particles, and these interfered with the accuracy of the measurements. The steel balls have since been replaced by small spheres of the alloy No. IX 3, and the difficulty in question has disappeared entirely.

The alloys described in Table I are also remarkable for their power of resisting corrosion, particularly the action of sea-water. Thus the alloys Nos. VIII 9 and VIII 13, respectively, lost 0.00087 and 0.00081 pound per square inch per month of 30 days, when completely immersed in the sea, while the loss in naval brass similarly exposed was 0.00124 and in Muntz metal 0.0123 pound, respectively. The behavior of the alloys IX 2, 3 and 6 is still more favorable. Specimens of these alloys which were immersed in the sea, and then exposed between wind and water for several years, show little more than a dulling of the surface.

The most serious objection to the use of these alloys is undoubtedly the difficulty of obtaining them commercially, as they are not manufactured so extensively as the older alloys of copper with zinc and tin, but once the value of these alloys is fully recognized there is little doubt that the enterprise of metallurgical manufacturers will meet any demands that may arise. This difficulty is one which applies to the introduction of every new material, and it is to be hoped that both instrument makers and metallurgical manufacturers will rise above any inherent conversatism in such a matter.

To be continued.

[1] Eighth report to the Alloys Research Committee of the Institution of Mechanical Engineers on the Properties of the Alloys of Aluminium and Copper, by H. C. H. Carpenter, M.A., Ph.D., and C. A. Edwards. (1907.)
Ninth report to the Alloys Research Committee of the Institution of Mechanical Engineers on the Properties of Some Alloys of Copper, Aluminium and Maganese, by W. Rosenhain, B.A., D.Sc., and F. C. A. H. Lantsberry. (1910.)
Tenth report to the Alloys Research Committee of the Institution of Mechanical Engineers on the Alloys of Aluminium and Zinc, by W. Rosenhain, B.A., B.Sc., and S. L. Archbutt. (1912.)

Non-Inflammable Cinematograph Films*

Celluloid, which is largely employed for cinematograph films, is allied to gun-cotton, being a nitro-derivative of cotton mixed with camphor. It is exceedingly inflammable, and may easily be ignited by a glowing match or cigarette end, while if heated to a certain temperature it may suddenly explode. Accidents, through this behavior of celluloid, have unfortunately happened very frequently. The chemical explanation of the danger of celluloid is simple. It possesses in itself all the important factors of combustion, including oxygen. Hence, even in an atmosphere of carbon dioxide celluloid will continue to burn, though flamelessly, less vigorously, and with much smoke. The smoke resulting from such a combustion consists largely of such gases as nitrous oxides, hydrocyanic acid, and carbon monoxide, which are not only extremely poisonous, but, when combined in certain proportions, are highly explosive and may cause a sudden darting flame. To smother a celluloid fire or to extinguish it by means of water is impossible.

ACETYL-CELLULOSE.

For years chemists have been busy in the search for a substitute for celluloid which, while equal in all other respects, shall be non-inflammable, and it now appears as if they have achieved success by the simple expedient of replacing the nitro group by an acetyl radical, the product being described as acetyl-cellulose. There exist a number of patents, the subject matter of all of which consists in the conversion of cellulose by means of acetic anhydride into the acetate, sulphuric acid, sulphurylchloride, dimethylsulphate, persulphates, bisulphates, being among the contact substances employed. From the thick, colorless, viscous fluid so prepared acetyl-cellulose is precipitated by means of water, benzol, carbon tetrachloride, or other reagent. The precipitate, after being washed and dried, takes the form of a white powder which is soluble in either acetone or chloroform. To get plastic masses additions have to be made which form the subject of secret processes. Under various trade names acetyl-cellulose is already a commercial article. Being an organic substance, it can be destroyed by fire, and hence in the strictest sense it is not non-inflammable. Wood or rolls of paper would, however, burn more readily.

There have been interesting controversies as to what constitutes an inflammable film. While, in general, it may be said that any film that will fire in the "gate" of the machine can be so described, the definition is not yet clear, and will no doubt form the subject of test cases in the near future. Technically, in the machine, there is now little difference between a celluloid and a well prepared acetyl-cellulose film, although the two differ fundamentally as to ignition. The latter point can be proved by a simple experiment. A stationary celluloid film in the projection lantern catches fire in a few seconds, while the non-inflammable film merely melts. To distinguish the two by outward appearance is, however, impossible, while as to the adhesion of emulsion and the suppleness of the base they are practically identical. When working a non-inflammable film the fact has to be taken into consideration that it generally expands more than a celluloid film in aqueous solutions, such as developers, fixing bath, etc. This expansion is, however, immaterial, as the film on drying resumes its original size. For this reason, when drying it on a frame, care has to be taken that the rungs yield sufficiently to allow for a shrinkage in the process. Non-inflammable films can usually be joined by means of a mixture of acetic acid and acetic ether, or epichlor-hydrine. The question whether they give as brilliant a picture and stand the same wear and tear as the ordinary celluloid films may be answered in the affirmative, and their cost is not much higher.

THE NEED FOR SAFER FILMS.

The manufacture of non-inflammable films is of comparatively recent date. Several years ago films so described were put on the market, but they did not prove a success, as they were brittle and otherwise defective, and the ordinary celluloid film suffered little by the competition. The need for a satisfactory non-inflammable film, however, is obvious. Apart from the enormous demand for films which are let out on hire for exhibition purposes, there is reason to believe that the educational side of cinematography will come more and more to the front. In fact, it seems safe to prophesy that one day the cinematograph will be largely used in the teaching of science to students and of elementary subjects to school children. To open up this sphere, the use of a non-inflammable film appears to be highly desirable, as the ordinary celluloid is too dangerous for use in school or college.

The question of increasing the precautions necessary when handling celluloid stock is occupying the careful attention of legislative bodies not only in England but also in several continental countries, and official discrimination between the inflammable and non-inflammable film is likely to follow. The main danger of the celluloid film lies perhaps not so much in the projection lantern, which is now provided with an automatic shutter and other safety appliances, as in the storage.

*From the Engineering Supplement of the *London Times*.

Native Laborers at Work on Cutting and Embankment.

A Bit of Typical Scenery in Cameroon.

The Northern Railway of Cameroon

A Difficult Task for the Engineer

By the Berlin Correspondent of the SCIENTIFIC AMERICAN

WHILE Cameroon, of all German colonies, is doubtless the one least opened up to civilization, great strides have been made in this direction of late years, especially through the exertions of a syndicate of influential men formed to provide the country with a railway system.

In 1902 there was sent out an expedition intrusted with the task of ascertaining the most suitable course for a main line leading from Duala, the most important harbor of the colony, into the interior of the country, this line being intended as the basis of a contemplated railway system. The track eventually chosen at first follows the watershed between the rivers Mungo and Wuri, and then enters Upper Wuri district, passing along the slopes of the Kupe Mountains and thence to the southern slope of the Manenguba Mountains, and terminating at the level of the defile between these and the Nlonako Mountains. This course was also the best solution from an economical point of view, as it crosses extensive areas covered with dense olive groves, and in the upper district excellent basalt soils, which experience has shown to be excellent land for plantations. The special survey preparatory to the construction of the line was begun in the summer of 1906, and was completed after two years' strenuous work. The construction of the railway was then imediately commenced by the contractors.

During this construction work, which has now been completed, 60 millions cubic feet of earth have been moved, corresponding to about 388 cubic feet per foot (the line being 96 miles in length); this comprised about 8,825,000 cubic feet of solid rock which had to be blasted by means of dynamite.

The difficulties met with in the construction of the railway were much more serious than in other African colonies, where at least some experience in railway building would have been available. Extensive tracts covered with virgin forests with luxuriant vegetation had to be crossed, the giant trees had to be felled and removed, trunk, root, and all. Exceptionally heavy rains also interfered with the work, especially in bridging the numerous rivers and ravines. The unfavorable climate of the sea coast district necessitated continued changes in the staff of employees and especially among the thousands of unskilled workmen. To this was added the necessity of crossing broad swamps and numerous creeks which entailed two or three times the ordinary expenditure of work. After the first 60 miles, the abrupt ascent to the mountains began, a level difference of 3,000 feet being overcome in clever serpentines, opening up a splendid panorama to the traveler's eye.

The Northern Railway of Cameroon, as it is called, comprises thirty-four bridges and vaulted viaducts, containing about 360,000 cubic feet of masonry and 330 tons of iron. The largest of these structures is a bridge over the Bomono Creek, which comprises two spans of 260 feet total length, and the next in order is the Dibombe Bridge, with a total span of 224 feet.

About 13,000 tons of iron and steel and about 297,500 cubic feet of broken stone have been used in laying the track. The stone ballast was obtained from the unlimited store furnished by the neo-volcanic districts crossed by the railway. Thus the White Mountain and its immediate surroundings consist of a porous, though substantial, lava, forming fragments from a hazelnut to a fist in size and thus constituting a natural ballast material of excellent quality. On the other hand, sand or gravel deposits, such as mainly used in Europe and America for ballasting railway tracks, are extremely scarce in Cameroon and, it seems, in other tropical countries.

The railway stations are equipped as simply as possible, though with due regard to the actual requirements of traffic. Those at which a more extensive traffic is anticipated were provided with a station building and waiting hall, luggage and office rooms and dwellings for the colored station master. Apart from the starting and terminal stations there are 18 intermediate stations, of which 12 have been equipped with station buildings. The average distance between two consecutive stations is five miles.

Water feeding stations for locomotives are provided at intervals of about 18 miles and comprise a pump, water tank and slewing crane. The repair shop is installed at the starting station, which is situated at Bonaberi.

The locomotives, of which there are five, are five-axle tender locomotives with four coupled axles, each 35 tons in gross weight. Sixty-four cars are at present in operation. A quay equipped with steam crane and store sheds has been provided at the Bonaberi station, for transferring goods from ships into the company's railway cars.

In view of the extensive forests of Cameroon, it was thought convenient to use wood in place of coal for firing the locomotives. This plan has so far given satisfactory results, coal being resorted to only in cases of emergency.

A maximum of 80 white and 3,260 colored workmen were employed at a time, the total number employed during the construction work being 236 white and 10,750 negroes.

Traffic has developed satisfactorily on the sections inaugurated during the construction of the railway. It is thought that this development will continue for a considerable time to come, the Northern Railway opening up one of the most populous districts of Cameroon, in which the olive tree plays a paramount part as an agricultural and commercial product. It is true that as long as traffic will mainly be based on native production, a maximum is likely soon to be reached, the natives being evidently unwilling to produce beyond a certain limit.

Proposed United States Aviation Field

Bill Before Congress for an Appropriation of $400,000

A BILL was introduced into the Senate and House of Representatives, authorizing the purchase of the aviation field at College Park, near Washington, D. C., and of property adjacent thereto, for aviation maneuvers and other military purposes. Provision is made in this bill for an appropriation of $400,000.

Mr. Edwin A. Newman, who has made a careful study of the conditions of the case, has submitted a report to the Hon. James Hay, Chairman of the Committee on Military Affairs, House of Representatives. From this report we quote a few pertinent passages:

"Several years ago, when the War Department was searching the country, for miles around, for a suitable field to instruct its aviators, I had the honor to bring to their attention and submit for their consideration the present aviation field at College Park, which was leased at that time for a term of six months and was then abandoned on account of lack of funds or appropriation for aviation. A year or two later, when an appropriation became available for aviation purposes the War Department again entered into a lease with me for the said field, containing about 275 acres. The lease on 200 acres, on which hangars and government buildings have since been built, was made with the privilege of renewal for a period of ten years, while on the 75 acres adjacent, known as Kropps' Addition to College Park, a subdivision in which a number of lots had been sold, the lease covered only the portion which had not been sold or contracted to be sold and this portion was only subject to renewal for three years.

"As there has been considerable activity in a portion of this subdivision and as the War Department may, under these conditions, be compelled to abandon this portion of the field, which would very much contract its area, it is exceedingly important that an appropriation be made without delay for the purchase of the present aviation field and also the additional land indicated on the said plot, as the continued activities, sales and development in that section would soon make its acquisition more difficult and expensive.

"The said field is the only available site anywhere near Washington. It lies east of the main line of the Baltimore and Ohio Railroad, between Washington and Baltimore, fronting on four railroad stations with sidings, as follows: Riverdale, College Park, Lakeland and Berwyn. It is a field of level land 2½ miles long, ¾ of a mile wide and only 7 miles from the capitol building. The City and Suburban Railroad parallels the field about one block to the west, the Washington and Baltimore Boulevard, about 2 blocks to the west, while the Washington Interurban Electric Railway and the Edmonston Road border the field on the east, the time to Washington by electric cars, steam or automobile being from 15 to 30 minutes. The old Calvert mansion, the former home of Lord Baltimore, and Riverdale Park border the field on the south, College Park with the Maryland Agriculture College on the high elevation, about ¾ of a mile away face the field from the west, Berwyn Heights on the north, while midway the field on the extreme eastern border there is a magnificient elevation suitable for observation purposes and officers' quarters, overlooking the entire field from Riverdale to Berwyn. The natural topography of the land is such, most of it being already cleared, that it can be made available for aviation purposes at a minimum cost. This location combines advantages which will make it one of the most beautiful aviation fields in the world.

The Reality of Molecules*

A Résumé of the Overwhelming Experimental Evidence Gathered Within the Past Decade

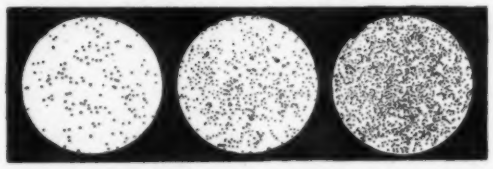
By Prof. T. Svedberg

ANYONE consulting a handbook of chemistry or physics written toward the end of the nineteenth century, to gain information regarding molecules, would in many cases have met with rather skeptical statements as to their real existence. Some authors went so far as to deny that it would ever be possible to decide the question experimentally. And now, after one short decade, how the aspect of things is changed! The existence of molecules may to-day be considered as firmly established. The cause of this radical change of front must be sought in the experimental investigations of our still youthful twentieth century. Rutherford's brilliant investigations on α-rays, and various researches on suspensions of small particles in liquids and gases, furnish the experimental substantiation of the atomistic conception of matter.

The modern proof for the existence of molecules is based in part upon phenomena which give us a direct insight into the discontinuous (discrete) structure of matter, and in part upon the "working model" of the kinetic theory furnished us in colloidal solutions. These last have been shown to differ from "true" solutions only in that the particles of the dissolved substance are very much larger in the case of colloids. In all respects they behave like true solutions, and follow the same laws as the latter. And, thirdly, the recent direct proof of the existence of indivisible elementary electric charges enable us to draw conclusions regarding the atomic structure of ponderable matter.

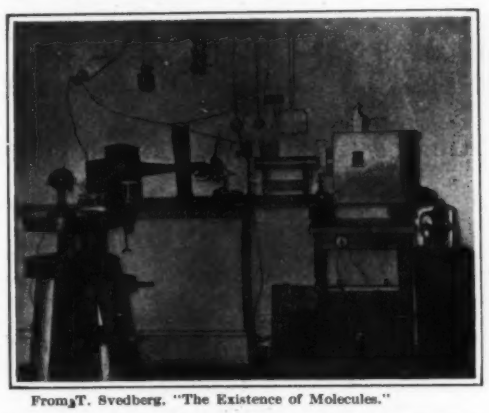
Among the first-mentioned class of proofs is Rutherford's great discovery (1902-1909) that many radioactive substances emit small particles which, after losing their velocity, as for instance by impact against the walls of a containing vessel, display the properties of helium gas. In this way it has been proved experimentally that helium is built up of small discrete particles, molecules. In fact, Rutherford was able actually to count the number of α particles or helium molecules contained in one cubic centimeter of helium gas at 0 deg. Cent. and one atmosphere pressure (1908). He thus found that number of molecules to be 26,900,000,000,000,000,000 or 2.69×10^{19}. From this follows directly the absolute mass of the helium atom, namely, 6.65×10^{-24} grammes. Rutherford (1908) and Requer (1908-1909) were the first to isolate an individual α particle, or helium atom. These two physicists showed independently that each α particle produces, on impact against a barium platinocyanide screen, a spark of light, a scintillation, which is observed with comparative ease with a microscope in a darkened room. An exceedingly neat electrical method of counting the α particles, i. e., for counting atoms, was discovered in 1908 by Rutherford, and more recently Wilson, Reingarum and Regener have worked out most ingenious methods for effecting the same purpose.

Another proof of the atomic structure of matter, also derived from the study of α rays, was worked out by the author. Consider a small volume of a solution or gas, inclosed within definite geometrical boundaries, though not physically shut off from the surrounding medium. If we think of this system from a non-atomistic standpoint, the concentration of the dissolved substance or gas within the volume considered should be constant, invariable with time. From the point of view of the molecular-kinetic theory on the other hand we must expect that, owing to the motion of the molecules, there should be now a greater, now a smaller number in the volume under consideration. According to the atomic theory, in other words, the concentration is not invariable in time. By an investigation of the α rays emitted by radioactive solutions I have, in point of fact, succeeded in showing that such variations in concentration do occur, and take place in accordance with the requirements of the kinetic theory. The method consisted in recording the number of α particles shot out against a small surface by a small volume taken somewhere within a larger mass of polonium solution or radium emanation, and comparing the record with a similar record obtained from a solid radioactive preparation. Owing to the "accidental" (chance) character of the disintegration of an atom, the α radiation even from a solid displays variations in time. These variations are however notably less than those observed in the case of a solution or gas, as will be seen in our third illustration. The state of affairs in the two cases thus compared may perhaps be illustrated by a simple analogy. Imagine a large field occupied by soldiers shooting at a target suspended over the field. The soldiers correspond to the radioactive atoms, the bullets to the α particles. Spread over the field is an armor plate with a small window in it, so that only bullets shot through this window can reach the target. We must suppose that each soldier shoots, reloads, shoots again, etc., in absolute independence of every other soldier. The number of bullets which strike the target per unit of time therefore varies from moment to moment. If the soldiers stand still, the case corresponds to that of a solid radioactive substance; if, on the other hand, they move irregularly to and fro over the field, they present a picture of a radioactive solution or gas. The mean variation in the number of hits will be greater in the latter case, because, added to the irregularity in the distribution of the shots in time, there are now variations in the number of soldiers standing under the "window" in the armor-plate.



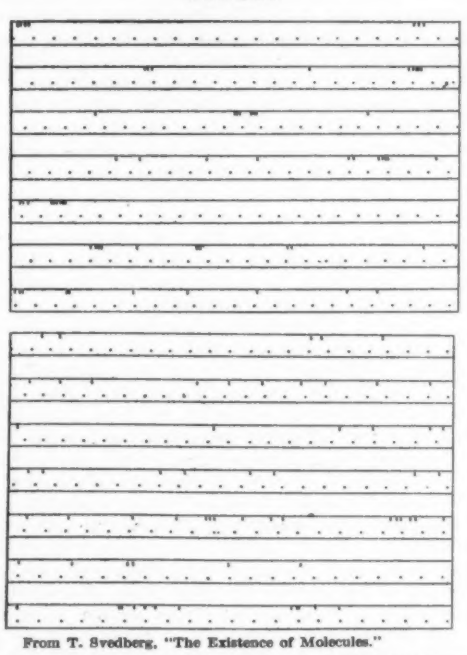
From J. Perrin, "The Brownian Movement and the Reality, etc."

Distribution of Density With Level in a Gum-mastic Emulsion. The Three Views Here Shown are Taken at Three Different Levels, Twelve One-thousandths of a Millimeter Apart.



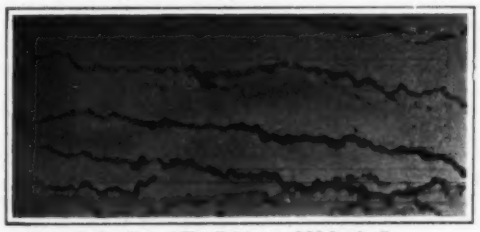
From T. Svedberg, "The Existence of Molecules."

Apparatus for the Photographic Study of the Brownian Movement.



From T. Svedberg, "The Existence of Molecules."

Record of α particles emitted from a solid preparation (above) and from a solution (below). The time is indicated by the equidistant dots, the α particles by the dashes. The average number of α particles emitted per unit of time is the same in both cases, but their distribution in time is much more irregular in the case of the solution than for the solid preparation.



From T. Svedberg, "The Existence of Molecules."

Photograph of Brownian Movement. This Record is Prepared by the Aid of Siedentopf's Ultra-Microscope and a Plate Moving Uniformly Across the Field from Left to Right.

The second class of proofs of the existence of molecules comprises a number of researches on the change of concentration with level which is observed in colloidal suspensions, and on the related phenomena of diffusion, Brownian movement, and light-absorption in such systems.

The first of these phenomena, variation of density with depth, was predicted from theory by Einstein and v. Smoluchowski and was experimentally demonstrated and studied in detail by Perrin. The density of our atmosphere decreases as we ascend to higher and higher levels, the law of the change being, that as the heights increase in arithmetic progression (i. e., by equal increments), the corresponding densities decrease in geometric progression (i. e., in constant ratio). Now the kinetic theory requires that in a suspension, which, as we noted above, represents an exact model of a true solution, the particles shall distribute themselves under the influence of gravity according to just the same law as that which governs the density of the atmosphere at different levels. Perrin's experimental work has furnished a brilliant vindication of these predictions of theory, and, in fact, on the basis of his observations, he has determined what is known as Avogadro's constant, namely, the number of molecules per cubic centimeter of a gas at 0 deg. Cent. and atmospheric pressure. He thus found 3.05×10^{19}, in very fair agreement, it will be seen, with Rutherford's determination, 2.96×10^{19}, made by an entirely different method.

When a solution is brought into contact with the pure solvent a transference (migration) of the dissolved substance from points of higher to points of lower concentration takes place. This is what is known as *diffusion*. Now if a colloidal solution really represents a model of a true solution, then the colloidal solution also must display the phenomenon of diffusion, and the velocity of diffusion should be that calculated according to kinetic theory. If the diffusion velocity is determined experimentally, and if the size of the particles is known, it is possible to deduce therefrom a value for Avogadro's constant, the third method which we have had occasion to note (Einstein, 1905). This determination was carried out by me in 1909 and 1911 by means of colloidal gold solutions, in which the little gold particles had a radius of about one millionth of a millimeter. In this way the constant of Avogadro was found to be 2.59×10^{19}.

Diffusion implies a proper motion of the particles in colloidal solution. Such a motion had, in fact, long been observed. Soon after the introduction of the improved microscope the English botanist, Brown, observed (1827) that small particles suspended in liquids perform a peculiar dancing motion. This so-called Brownian movement was studied by numerous workers during the nineteenth century, but without shedding any definite light on its cause. Some years ago Einstein and v. Schmoluchowski developed the theory of the Brownian movement on the basis of the kinetic theory, and since then it has been demonstrated experimentally by the work of Perrin, Sedig, Millikan, and myself, that the Brownian movement is a true molecular motion, i. e., obeys exactly the same laws as have been developed by the kinetic theory for dissolved molecules. As early as 1906 I showed that the general character of the motion of the particles in colloidal solution corresponds to the conclusions of the kinetic theory, and in 1907 Seddig demonstrated that the increase in the Brownian movement with temperature is in accord with that theory. More recently the work of the French physicist Perrin and Prof. Millikan of Chicago University (in collaboration with Fletcher) has brought the most convincing vindication of the kinetic theory in its relation to the Brownian movement. Perrin calculated Avogadro's constant from his experimental results as 3.07×10^{19}. In pur-

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Prometheus*.

suance of my experiments of 1906 I personally investigated the Brownian movement of gold particles in water, and found for the Avogadro constant the value 2.78×10^{19}, in excellent agreement with Rutherford's very reliable result, 2.69×10^{19}. A very similar result was obtained by Millikan and Fletcher (1911) by a new and highly ingenious method based on the observation of particles suspended in air.

Another point of great theoretical significance is the proof which a study of the Brownian movement has brought of the so-called theorem of the equipartition of energy. This theorem states[1] that in a system in equilibrium, comprising molecules of different types, and, therefore, of different masses, the mean kinetic energy of the molecules of one type is the same as that of a molecule of any other type. Thus, if we have a mixture of hydrogen gas and nitrogen gas, the average kinetic energy of the hydrogen molecule, $\frac{1}{2} m_1 v_1^2$, will be equal to that of a nitrogen molecule, $\frac{1}{2} m_2 v_2^2$. This evidently leads directly to a relation between the mean of the squares of the velocities, namely, $\frac{v_1^2}{v_2^2} = \frac{m_2}{m_1}$ or, in the case of our example, $\frac{v_1^2}{v_2^2} = \frac{28}{2}$. The reasoning by which this conclusion was originally established on the basis of the kinetic theory has been the subject of repeated attacks from highly competent critics, and it can hardly be said that, from the standpoint of theory alone the question has ever been settled beyond all doubt. But now we have proof positive provided by purely experimental evidence. The gold particles employed by the author in his work weighed 0.000,000,000,000,000,000,18 gramme, while Perrin used gum mastic emulsion with particles weighing 0.000,-000,000,56 gramme. The ratio between these two is, therefore, no less than 529,000,000, yet the law of equipartition was found to hold even in this wide range, vastly surpassing the range of molecular weights of ordinary molecules as known to present day chemistry.

Another line of research followed by the author takes up the investigation of the absorption of light in colloidal and in true solutions, and shows that, as the size of the colloidal particles is diminished, the law of absorption of light in colloidal solutions approaches that which holds for true solutions (1909). In this regard also, therefore, their behavior toward transmitted light, the two kinds of solution agree essentially, and there is every indication that both have a similar ultimate structure, i. e., that true solutions also are built up of discrete particles, the molecules.

And, lastly, modern investigations of the conduction of electricity through gases, and of the so-called β rays, have shown conclusively that electric charges, like matter, are of atomic nature, i. e., composed of ultimate elementary charged particles, whose mass is only about 1/700 of a hydrogen atom. Quite recently Millikan and Regener have succeeded by entirely different methods in isolating an electron, and studying it directly. Millikan found that the charge of a single electron has the constant value of 4.777×10^{10} electrostatic units. Inasmuch as one gramme of hydrogen conveying an electric charge, one gramme of hydrogen ion, as it is termed, transports 2.88×10^{14} such units of electricity, it follows that the number of hydrogen atoms in one cubic centimeter, i. e., Avogadro's constant, is 2.7×10^{19}. This is in excellent agreement with Rutherford's value 2.69×10^{19}.

We see, then, that the scientific work of the past decade has brought most convincing proof of the existence of molecules. Not only is the atomic structure of matter demonstrated beyond reasonable doubt, but means have actually been found to study an individual atom. We can now directly *count* and *weigh*[2] the atoms. What skeptic could ask for more?

[1] For the sake of those readers who may not be very familiar with the subject, the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT has here amplified somewhat the author's presentation.

[2] This review of our recent contributions to our knowledge of molecular physics would be incomplete without a reference to Sir J. J. Thomson's remarkable work, on which we reported in the issue of October 26th, 1912. As our readers will remember, the great English physicist causes the atoms themselves, in "falling" through an electric and a magnetic field, to record their mass.—EDITOR.

The Educational Work of a Great Museum*

What Are the Chief Functions of a Museum?

By Harlan J. Smith, Dominion Archæologist, Ottawa, Ontario

THE educational work of a museum should be governed entirely by the purposes for which the museum is established. The very greatest museums may give pleasure to the public, may educate the more intelligent groups of people, among which are college graduates, may educate such classes as teachers and children, and should not neglect the education of the masses. One of the most important services to education which a great museum can accomplish is to carry on surveys, explorations and original investigation, and it is only from such work that any facts are learned which may in turn be given out to mankind by means of exhibits, popular guide-books, scientific reports, lectures and contributions to encylopedias, text-books, popular magazines and newspaper accounts. Great care should be taken that research work is never neglected in the stampede for "popularization." Such great museums may also have departments for special classes of the people, as for instance blind people and kindergarten children.

Special museums must serve the specialty for which they are founded, and small museums also have to confine their work to a narrower scope of educational endeavor. Provincial museums seldom have sufficient funds to make world-wide investigations or teach all subjects, and it is perhaps best for such a museum to devote itself solely to its own province or certain subjects. The same is also true of a county, and in some cases a city, museum. The university museum should serve the purposes of the university, its students and professors, that is, supply illustrative material for classes, provide for the research necessary to keep professors up to date, and allow advanced students actual research experience. In common honesty its funds should not be used primarily for the general public or for subjects outside the line of the university's work. An art museum must confine itself to esthetics or other branches of art endeavor. A commercial museum of course should keep its attention on work of a commercial nature. It is evident that there are many methods of museum administration, each of them good in its own place and each of them bad or even dishonest when out of place.

A museum building should be constructed so that additions may be made to it without ruining its architecture or causing unnecessary expense for remodeling or making connections. Such a building should be built with a view to its purpose so that the laboratories, offices, exhibition halls and the like may be properly lighted and each suitable for its special kind of work. In the past museums have usually been built to please an architect and the result is that most museum buildings are abominably adapted to the use of the museum and its staff. The day must soon come when museum buildings will be constructed with a view to the purpose for which they are to be used and then the result of museum work will be even more worth while than at present.

No matter what the scientific investigator and the teacher may say, one of the justifiable purposes of a museum is to give recreation and happiness to great masses of the people and by far the greater number of visitors to the large museums drop in casually for just these purposes. Very few of them come to be educated or to carry on research, but from the casual visits many people carry away a desire to investigate and still more to receive educational benefits.

The educational section of a museum may be likened to extra illustrated text-books. For instance, in text-books on birds, we may have pictures of birds, even colored pictures, but in a museum we have the actual birds, their skeletons, their organs, their nests and their eggs. Thus a large collection of birds in a good educational museum is like a great text-book on birds illustrated by these things, while the labels take the place of the printed matter in the text-book. Educational popularization should never be carried to the extreme of exaggeration and untruthfulness affected by certain schools of museum employees.

A museum may also serve as a great warehouse where are kept such valuable things as individuals should not horde in their homes. For instance, an object from which something may be learned, and which is the only object of its kind in the world, should not be kept in a home where it may be destroyed by fire, but in a fireproof museum; nor ought it to be where its owner and his friends are the only ones able to see it, but it should be available for all who may desire benefit from it, whether they be citizens of the province or nation owning the museum, or visitors from the most distant lands. No museum should be a collection of merely curious things.

Sometimes animals, plants and the like are exhibited surrounded by representations of their natural home and in front of a painting representing the country in which they occur. Such exhibits depend for their excellence on the skill of the scientist who plans them, the collector who secures the material and artists and mechanics of various kinds. Each of these does a particular share of the work which he is perhaps the only man able to do. The artist may be brought thousands of miles because of his ability to paint just the right kind of background. The museum expert is skillful in writing labels which may be understood not only by the scientist, who often knows all the facts without any label, but also by the people who do not know the facts and consequently need information. Such a man should write the label.

In a great research museum there are always thousands of specimens in the storerooms and laboratories kept for study and research; that is, they are used for the increase of human knowledge. To expose them to the light and dust of exhibition might destroy them while duplicate specimens, pictures, casts and models may serve equally well or even better for educating the public.

All great museums have brains, in other words they have a staff of experts who perhaps are not seen in the exhibition halls, but who find out the new knowledge which the people are always anxious to have, who plan the work, write the labels and guide-books, give the lectures, direct the field explorations and so keep the museum from ever being dead and dusty. One of the great museum men of the world once said that a finished museum was a dead museum, and this well expresses the idea that there is no such thing as a finished museum, for scientists are always making new discoveries which lead them to add new exhibits and rearrange old ones. There is always a great deal of work going on in the workshops, of which the visitors to the exhibition halls have little idea. This work can not be done by untrained men, but must be accomplished by artisans, mechanics and artists who have had very special training each in his own particular line. Sometimes in a country of millions of inhabitants there is no man trained in a certain special kind of work so that a museum often has to send across the sea or to some equally far-away place for a skilled mechanic. Even Japanese, Eskimos and Indians are employed in one of our largest museums. Many days' and sometimes months' work must be done—not by one man but by seven or eight men, each doing his own kind of work in the most expert way—to produce an exhibit from which the public may learn in a few moments what has taken all this time to produce. Then, too, one must not forget that to get some material by means of which new knowledge is found out, and by means of which this knowledge is diffused to all the world, hardy men must penetrate into the uttermost wilds of the earth, endure the bitter cold of the Arctic and the dangers of the tropical forest.

Some museums have many friends, for instance for years the Barnum and Bailey circus had all of its rare animals which died on the road embalmed or otherwise preserved and sent to one of the museums in New York city. Then, too, wealthy men vie with each other in giving funds for expeditions, research, scientific books, exhibits, teaching labels and guide-books, and for lecture courses in connection with these museums. Sometimes they endow a branch of museum work or an entire museum. Some men have each given more than a million dollars for such purposes and this is one of the indications of the value of a museum, for men capable of amassing millions do not endow institutions which they consider valueless.

Sometimes models teach quite as much as actual specimens. A model of a mosquito made many times larger than the insect itself shows us how to cope with malarial fever and yellow fever. We could not see the means by which the mosquito transmitted these diseases by looking at the mosquito herself, but the scientist in his laboratory with his microscope may find out all these things, make accurate plans and drawings of the various parts of the insect, and leave it to skilled mechanics to spend many months in reproducing them accurately on a large scale. Such work is not an extravagance when we consider that if the doctors and the people learn to avoid yellow fever and malaria the life insurance companies do not have to pay so much life insurance and the amount paid for one death is easily sufficient for the construction of such a model.

Pictures are very useful in connection with museum exhibits. Sometimes photographs are used, again

* An abstract of an illustrated lecture delivered, in anticipation of the opening of the Victoria Memorial Museum, the national museum of Canada, at the inauguration in Ottawa of free lectures to the people under the control of the school board.

ketches or paintings or transparencies, and frequently lantern slides are employed. These pictures may show the sort of country from which the objects come, or they may be reconstructions based on careful study. For instance, bones of extinct animals are frequently found. No one knows what these animals looked like in life, but the scientist can study the bones and compare them with the bones of animals which he is able to observe. He can have his artist paint these living animals and can explain to him in what respect the bones of the extinct animal differ. By a study of the bones of the feet he may learn and explain to the artist whether the animal walked in a swamp or on rocky ground. By a study of the animal's teeth he may tell what kind of food it ate. Then the artist can make his picture very much more intelligently than otherwise would be the case and this picture conveys to the people some idea of what the animal formerly looked like. Sometimes the artist makes a sculpture of the animal instead of a painting or to accompany the painting so that a complete exhibit might show a skeleton with a painting, a model, a label, a map, and perhaps even another animal such as lives to-day and is akin to the extinct animal.

A map may show the part of the world from which a specimen comes, other maps may show the details of its home country, and maps may be used to show its distribution over the earth and the relation of this region to some other area, as for instance one where certain plants grow. Maps may be mere outlines or shaded, or they may be relief models made to resemble a surface of the country.

Specimens may be arranged in series, and in this way teach much more than they would singly. One may arrange together specimens which illustrate the idea of evolution or which show all the different musical instruments of the world. One may show together all the things found in a certain province or all the animals, plants, minerals and so forth, of a certain region, as for instance, a desert, and contrast them with things from a forest.

Different classes of people use museums. Carpenters and cabinetmakers often study the collections of woods, miners the collections of minerals, teachers of art and architecture the collections of primitive art and the objects and pictures showing the types of buildings of other times and other peoples.

Some collections are of great value, as for instance the display of gems exhibited by Tiffany & Co. at the Paris Exposition. Such a collection is sometimes protected by iron gratings on the windows, and armed guards night and day. Then, too, there may be electrical connection with the police department so that an alarm may be given either by the guard or when a case is broken open.

Exhibits showing mankind occasionally include plaster casts of living people. Placed on these casts are their clothing, the whole being arranged so that it will illustrate their occupations and their relations to the country in which they live as well as its products, both plant and animal.

Frequently pictures or casts or models must be used where the original specimens are too expensive or too large and heavy to be brought to the museum or even too large to be given space in a museum. Then, too, casts may be used for such things as can not be removed from countries which have laws preventing their exportation.

The expeditions of a great museum often cover practically the whole world. The American Museum of Natural History in New York in one year had expeditions in many parts of North America, in South America, Asia and the South Sea Islands.

The specimens too valuable for study to be put on exhibition, duplicate collections which are used for study and the specimens for which there is no room in the exhibition halls are kept in rooms for study where they are safe from changes of climate, insect pests, dust and careless handling. Some of these collections which are never seen by the public, unless they ask to visit the storage rooms, are vast in extent. In a great museum they may be of more value and consist of a larger number of specimens than is found in all the museums put together in a region as large as Canada and the States west of the Mississippi. These collections are of course placed as close together as possible and yet be able to get at them for research and for use in illustrating truths to visitors.

When an expedition goes out from a great museum and learns something new, the facts are published in reports which are ofttimes illustrated. This is partly because a single manuscript giving the facts might be burned or lost. These reports are then sent to perhaps a hundred different libraries widely scattered so that they may be available as nearly as possible to all the people of the world. That is, they should be found in such places as London, St. Petersburg, Tokio and Melbourne. It is from such reports that the writers of encyclopedias, text-books and magazine articles secure the knowledge which is finally the common property of all.

A great educational museum always has a library from which its publications are sent out and in which anybody may read works on the subjects covered by the museum. One of the great uses for the museum library is that the staff may always inform itself, for it would not be economical to send an expedition to gather facts about a place if all those facts could be read from books.

After the return of an expedition and after its reports have been published the specimens are put on exhibition together with labels, such a report, popular guide-books, maps, photographs and pictures. Sometimes the results are illustrated by models. Lectures are given to scientific colleagues, to highly educated people, to children, and to the general public, each lecture being made as far as possible appropriate to the audience. The reports contain all the facts, many of which are uninteresting to the public to-day but which would be lost unless published and which may some day be of such great value that they deserve to be saved. These reports are sometimes placed with the exhibits for the use of those who wish to read them, but more often extracts of the more useful and interesting parts are made and published as guide-books for all the people. In some museums such guide-books are given to the public, but as certain classes of people throw them away or destroy them, other museums prefer to charge a small sum for guides. This charge may be less than the cost of the book.

A few museums allow space for special and temporary exhibits and in this way become a sort of headquarters for all kinds of educational expositions such as flower shows, and exhibits illustrating the advance in the fight against the great white plague, expositions of modern sanitary methods and horticultural exhibits. Then, too, some of the great museums serve as centers for scientific and educational meetings, the large lecture hall being particularly appropriate for general meetings, and the smaller rooms for special societies.

The photographs taken on expeditions are kept in files or in scrapbooks where they may be consulted and copies are given out in small numbers free of cost or in large quantities for the actual cost of the photographs without regard to the expense of the expedition necessary to secure them. These are given to scientists for study and for illustrating their books. They are given to educators to use as illustrations and to hold up before their classes. Many of them are used by magazine writers and newspaper men for illustrations and by sculptors and painters. In this way the explorer brings back glimpses of far-away lands which eventually are shared with people unable to travel or who must travel nearer home.

Vast collections of lantern slides are also maintained in some of the great museums. These are used to illustrate scientific, educational, or entertaining lectures both in the museum and elsewhere. Moving pictures are also occasionally used.

A large lecture hall seating over one thousand people is a useful feature of some of the great museums which also have as a rule several smaller lecture halls. As many as seven or eight lectures may be held in such a museum in one week, as for instance one for the scientist, three in the afternoons for school children, two in the evenings for the general public, and other lectures for certain special classes of people, as for instance those interested in breeding or sanitation.

All the educational work of the museum exhibits is not confined to the inside of a great museum. Special cases of specimens are prepared and sent out to schools, libraries and other suitable places. Sometimes these are loaned indefinitely but very often they are loaned for a week and then moved to another place. In New York this feature of the work became so extensive that an automobile was purchased to transport the collections from the museum to the schools and from school to school, so that thousands of children were reached. This sort of work is somewhat akin to the work of branch banks and traveling libraries.

Many of our people do not appreciate the real use of a museum and we do not wonder at it when we see the dusty, poorly arranged collections in many museums where there are few, if any, labels and the whole tends to disgust, in fact to teach disorder rather than to be pleasing, helpful or educative, but in an up-to-date museum every day you may see classes from kindergartens enthusiastically examining specimens under the guidance of a museum kindergartner. Frequently one may see classes of bright high-school or college students on a visit to the museum halls, supplementing their educational work by viewing the actual things of which they study. They may be guided by a curator. Thousands of slum children in the greater cities are cheered, educated and uplifted by being taken to the museums by their teachers. One time when a lecture was advertised for school children by an enterprising newspaper which offered a prize for the best essay on a certain subject, over seven thousand children endeavored to attend the lecture held in a hall seating only one thousand four hundred, but one of the museum authorities sprang to his telephone and in as many minutes had twelve of the staff taking as many groups of the children to various parts of the building where they were entertained and instructed.

A great educational museum is usually open free to the public every day in the year so that people engaged on certain days may have the greatest possible opportunity to visit it for recreation, education or research. On the occasion of an exhibit for the prevention and cure of tuberculosis, in one museum over forty thousand visitors passed between the police lines in and out of the exhibit in a single day, which proved conclusively that the public is thoroughly alive to the importance and value of the most modern and useful museum work.

Mental Tests to Grade Pupils at School

At the recent meeting a number of test sheets were distributed, to be filled in by school teachers from observations or their pupils, and returned to Mr. W. H. Pyle.[1] These tests may be of interest to the general reader, and we therefore reproduce here brief extracts from the sheets.

I. ATTENTION TEST.

1. Material: A page of printed matter.

2. Time, 2 minutes in grades 2, 3, and 4; 90 seconds in grades above.

3. Tell the pupils to draw a line through every A on the page and to do it as fast as possible without making mistakes. Show sample sheet inclosed.

4. Grade the work by finding the number of A's cancelled per minute.[2]

II. ASSOCIATION TESTS.

1. *Uncontrolled Association.*—1. Time, 3 minutes. 2. Directions: Tell the pupils to write down as fast as they can the words that come into their mind. When you are ready, give them the word "play" to begin with. They must write play and the other words they think of. 3. The grade is the total number of words written.

2. *Part-whole Test.*—1. Material, sheets with the proper heading. 2. Time, 60 seconds in grades 2, 3, and 4; 45 seconds in grades above. 3. Directions: "Write opposite each word the name of the whole of which the Word names a part; i. e., for finger, you could write hand." 4. The grade is the number of words written.

3. *Genus-species Test.*—1. Material, the sheets with the proper heading. 2. Time, 60 seconds in grades 2, 3, and 4; 45 seconds in grades above. 3. Directions: "Write, as fast as possible, opposite each word, the name of an example of the thing named by the word, for example, for animal, you could write horse."

4. *Opposite Test.*—1. Material, the sheets with the proper heading. 2. Time, 60 seconds in grades 2, 3, and 4; 45 seconds in grades above. 3. Directions: "Write by each word in the list another word that means just the opposite, for example, for *high* you could write *low*." 4. The grade is the number of words written.

III. ROTE MEMORY.

1. Material:

Concrete.	Abstract.
1. Street, ink, lamp.	1. Time, game, scheme.
2. Spoon, horse, chair, stone.	2. Grade, fact, work, thing.
3. Ground, clock, boy, chalk, book.	3. Pluck, love, blame, fear, proof.
4. Desk, milk, hand, card, floor, cat.	4. Space, force, pride, fright, joy, size.
5. Ball, cup, glass, hat, fork, pole, cloud.	5. Length, light, style, rate, cause, youth, hate.
6. Coat, girl, house, salt, glove, watch, box, mat.	6. Law, thought, plot, glee, life, call, price, strength.

2. Method: There are 6 groups of concrete and 6 of abstract words. Read each group separately, slowly and distinctly. After reading a group, have the pupils write down as many of the words as they can remember, giving a reasonable amount of time to write the words.

3. The grade is the total number of words remembered. Record the concrete and abstract grades separately. Tell the pupils to write the words in the proper order and allow 2 for a word in its proper order and only 1 if the word is not in its proper order. Before beginning, have the pupils prepare and number the paper for that group of words, if a word cannot be remembered a blank should be inserted there, thus: 1, street,
2, ... (not remembered),
3, lamp.

Automobile Show at Barcelona.—An event which will be of considerable interest to the automobile industry is the show to be held at Barcelona under the patronage of the King of Spain. The exhibition is being organized by the local automobile club, and is to be held at Turo Park where extensive quarters have been provided. This locality is within a short distance of the center of the town. The French industry will be well represented. Figures now available show $800,000 of purchases in France for the first 11 months of 1912, from which it will be seen that the constructors are awake to the possibilities of the automobile trade. The De Dion, Renault, Hotchkiss and other leading builders have secured exhibition space. The show will last from March 8 to April 2.

[1] 209 Thilly Avenue, Columbia, Mo.

[2] It is to be observed that no provision is here made for taking into account the number of errors (omissions).—Ed.

In the Background of the Stars*

Worlds in the Making

By Prof. C. A. Chant

Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 1.—Photograph of the Great Nebula in the Constellation of Andromeda.

Taken by Ritchey at the Yerkes Observatory with a 24-inch reflecting telescope.

In astronomy, as in every other study, the deeper one dips below the surface the more interesting it becomes. When we look into the sky on a clear dark night, the numerous stars in their various magnitudes and mystic groups arouse in us the profoundest speculations. There is enough in a naked-eye study of the heavens to provide thought for many days. But with the slight optical assistance of an opera glass or a small telescope the spectroscope and the photographic plate reveal secrets which, a hundred years ago, were thought inscrutable.

Astronomy is indeed greatly indebted to photography, and in no way has this indebtedness been rendered more evident than in exhibiting the extraordinary forms and the delicate beauty of those faint, filmy objects known as nebulæ. These bodies in many instances are so faint that their light cannot directly affect the eye, even though it be assisted by a large telescope; but the sensitive photographic plate, drinking in the weak illumination for several hours together, at last accumulates a record which is made permanent by the familiar process of developing and fixing in the dark room.

The nebulæ appear to be just in the background of the stars. In many instances we have good reason to believe that some stars are actually surrounded by nebulæ, and that the nebulous matter is condensing to form them into suns like our own. Indeed, some photographs show that extensive portions of the sky are simply filled with the gauzy nebulous substance. A good illustration of this is shown in Fig. 7, which is from a photograph obtained with an exposure of five hours. All the chief stars of this famous group, the Pleiades, are enmeshed in the nebulous matter.

There is only one nebula in the sky which is certainly recognizable as such by the unaided eye. It is in the constellation Andromeda, and as there is a real pleasure in being able to identify an object like this, I shall explain a convenient way to locate it.

I hope that those who read this will not have forgotten that the stars cross the sky from east to west just as the sun and the moon do. This is caused by the rotation of the earth on its axis. Also remember that the stars change with the seasons. This is produced by the yearly revolution of the earth about the sun. Now Andromeda is almost directly overhead at midnight on October 1st, at 10 P. M. on November 1st, and at 9 P. M. on November 15th.

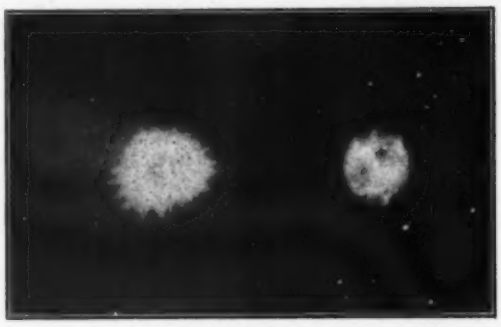
Of course every one can identify the Pole Star, and the constellation Cassiopeia will also be recognized at once. Its chief stars form a sprawling W, and in the autumn it is seen above the Pole Star, on the opposite side from the Big Dipper. That star in the W which is farthest to the west is called Beta of Cassiopeia.

Now, beginning at the Pole Star, draw a line through Beta of Cassiopeia, and continue it about an equal distance. It will reach a bright star, of the second magnitude, known as Alpha of Andromeda. The line so drawn almost coincides with the equinoctial colure, "the first meridian of the sky," which is used as a reference line for locating objects in the sky, just as the meridian through Greenwich is used on the earth. This star, with two others almost equally bright and nearly in a straight line, are the chief stars in the constellation Andromeda. The middle one of the three is called Beta, the other one Gamma (Fig. 6). Notice also that the star Alpha of Andromeda, with Alpha, Beta and Gamma of Pegasus, form the Great Square of Pegasus. All these features are prominent and will be easily identified.

Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 3.—A Spiral Nebula in the Great Bear.

From a photograph taken at the Lick Observatory. Exposure 4 hours.



Courtesy of the *Journal of the Royal Astronomical Society of Canada*

Fig. 4.—A Drawing of the "Owl" Nebula.

Made with Lord Rosse's 6-foot reflector in 1848, and a photograph taken at the Lick Observatory in 1898.

Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 2.—Sir John Herschel's Drawing of the Great Nebula in Andromeda.

The dot at the right hand lower corner represents the solar system on the same scale.

Now return to Beta of Andromeda and run a little to the north and west of it (about 8 degrees), and you will reach the Great Nebula. It appears like a star seen through a haze, and you may have to look for a while before recognizing it. If an opera glass is convenient use it, and you will then have no doubt about the nebula. It will appear like a slightly oval hazy patch of light.

The first recorded observation of this object is by Simon Marius, a German, in 1612. Galileo invented his telescope in 1610, and Marius was one of the first to apply it to astronomical observations. In the center of the nebula he observed a condensation of light, which he compared to "the flame of a candle seen through a leaf of transparent horn."

It is interesting to compare some of the drawings of this object with pictures obtained by photography.

In Fig. 2 is reproduced a drawing of it made by Sir John Herschel, with the assistance of a powerful reflecting telescope. His description is as follows: "Its form, as seen through ordinary telescopes, is a pretty long oval, increasing by insensible gradations of brightness, at first very gradually but at last more rapidly, up to a central point, which though very much brighter than the rest, is decidedly not a star."

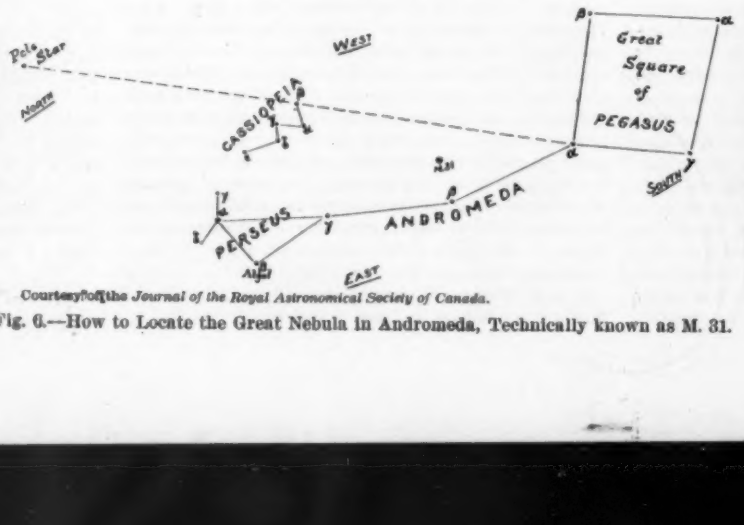
In 1848, G. P. Bond, after a prolonged study with the 15-inch refracting telescope of the Harvard College Observatory, published the drawing which is reproduced in Fig. 5. From this time opinion was divided as to whether the nebula was of a regular oval shape or of an irregular form, until a very decisive answer came by photography in 1888. Isaac Roberts, after a successful career as contractor and builder in Liverpool, retired and devoted himself to astronomy. He secured the construction of a high-grade reflecting telescope of diameter 20 inches and began the photography of faint objects such as nebulæ and star clusters. One of his earliest and greatest results was a photograph of the Andromeda nebula, which settled the question as to its form forever. Fig. 1 is from a photograph made at the Yerkes Observatory with a 24-inch reflector constructed by Ritchey. It is very similar to Roberts' picture. A close examination shows that the nebula is really spiral in structure, being seen by us partly on edge.

There is only one other nebula which can be considered in the same class as that just described. It is in the constellation Orion, being a little below the three well-known stars which form the Belt of the Giant. It would hardly be recognized as a nebula by the naked eye, but an opera glass easily reveals its nature. As a rule, nebulæ are not striking objects in the telescope, but this one is an exception. Even in a small instrument it is wonderful, though it lacks much of the beauty shown by a larger one.

Courtesy of the *Jl. Roy. Astro. Soc. Canada.*

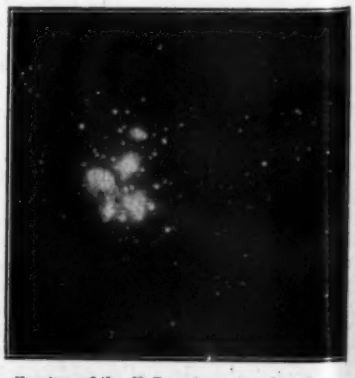
Fig. 5.—Bond's Drawing of the Nebula in Andromeda.

Using the 15-inch Harvard Telescope, 1848.



Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 6.—How to Locate the Great Nebula in Andromeda, Technically known as M. 31.



Courtesy of the *Jl. Roy. Astro. Soc. Canada.*

Fig. 7.—The Pleiades.

Photographed with an exposure of 5 hours. Notice that the entire group is surrounded by nebulous matter.

* Reprinted, with slight alterations, from *The Westminster* (Toronto), for November, 1911.

Great patience and care have been expended by skillful astronomers in drawing this object, and, it must be acknowledged, with considerable success. But the results cannot be compared with those obtained by photography. Bond spent over one hundred hours in carefully drawing the nebula, while an exposure of half-an-hour in a good reflector will exhibit a wealth of detail with an accuracy not approached by any drawing. Fig. 8 is from a reproduction of Bond's famous drawing, while Fig. 9 is from a photograph taken by Ritchey at the Yerkes Observatory with a 24-inch reflector.

This is an excellent example of a nebula without any regular form. On the other hand, Fig. 3 shows one of a very definite form. There is no question about it being a spiral; but although this is clear enough in the photograph, on account of its extreme faintness it would scarcely be recognized as such in a telescope. One cannot look at this picture without feeling almost certain that the nebula is in motion. Those arms are surely revolving about the central condensation. However, we have no unquestionable evidence of any such motion. Our trustworthy photographs of these objects have not been taken at times wide enough apart for us to recognize any change in the interval. One of the most interesting cases of a suspected change is illustrated in Fig. 4, in which is reproduced a drawing made with Lord Rosse's great 6-foot reflector in 1848, and also a Lick Observatory photograph taken fifty years later. The change exhibited is too great to be attributed to faulty drawing, but it may have been produced by the motion of the star from the eye of the "Owl" rather than by any change in the nebula itself.

There are many interesting questions regarding nebulæ, but I can refer to only two.

How many nebulæ are there? Charles Messier was a French astronomer who spent most of his time hunting for comets. Now the ordinary comet closely resembles a nebula, and in order to avoid confusion of the two kinds of bodies, Messier made a list of nebulæ. It was published in 1781 and contained 103 entries. In this list the Great Nebula in Andromeda is numbered 31, that in Orion is 42, and the "Owl" is 97. Sir William Herschel by 1802 had discovered 2,500 more, and in 1864 Sir John Herschel, his son, made a catalogue of all then known, amounting to 5,079. Dryer's catalogue, compiled in 1887 and added to in 1894, contains 9,369 nebulæ, of which more than half were discovered by the two Herschels. Quite recently Perrine, from photographs of representative portions of the sky, taken at the Lick Observatory by Keeler and himself, has estimated the number at not less than 500,000.

What are the nebulæ composed of? For many years it was thought that they were simply clusters of stars closely packed together, and that all that was required to exhibit the individual stars was a sufficiently powerful telescope. The spectroscope has demonstrated that this view was erroneous. We know with absolute certainty that some are simply masses of luminous gas. The Orion nebula is one of these, but that in Andromeda seems quite different. Our best observations go to show that the latter is probably composed of stars, and it has been surmised that it is similar to our Milky Way, but so distant that it appears like a nebula. For some time it was thought that the irregular nebulæ were gaseous in nature and that the regular ones were aggregations of stars, but that has been proved incorrect. No simple law like this can be enunciated. The more we learn of these strange bodies the more complicated is the problem of their nature.

Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 8.—The Great Nebula in Orion.
From Bond's Drawing, published in the Harvard College Observatory *Annals.*

Courtesy of the *Journal of the Royal Astronomical Society of Canada.*

Fig. 9.—The Great Nebula in Orion.
Reproduced from a photograph by Ritchey at the Yerkes Observatory.

The Autostable

A Flying Machine Possessing a High Degree of Automatic Stability

By Capt. W. I. Chambers, U. S. N.

THE subject of automatic stability of aeroplanes is one which has been much discussed, as indeed is only natural in view of its obvious importance. But, in spite of the numerous suggestions and experiments which have been made in this direction, it can hardly be said that any signal success had been recorded until recently. If first accounts are to be relied upon, it appears, however, that a very marked step forward has been made, as regards automatic stability, by the use of specifically designed tandem planes which have been studied by Mr. Eiffel and discussed by Mr. Andrews, in SCIENTIFIC AMERICAN SUPPLEMENT of October 26th, 1912 (p. 258). Mr. Drzewiecki seems to have been the first to reduce to aviation practice the principles thus worked out in Mr. Eiffel's laboratory, and to design in accordance with them an "autostable" machine.

The object of Drzewiecki's tandem plane design is so to adjust the planes, that when exterior perturbing forces disturb the equilibrium, a dynamic couple is created, which restores the equilibrium immediately and automatically. Of the two tandem surfaces, the forward one is smaller than the rear. This combination has appeared on other French machines, the "Canard" (or duck) type, but there is an essential difference between the two. In the "Canard" the forward surface, which forms the elevator, is very small in comparison with the rear surface, in consequence of which the center of gravity is nearly under the latter. In the "Autostable," the difference between the size of the planes is less, and the center of gravity is found near the middle of the fuselage, or body. This is important, because the horizontal position of the center of gravity influences the nature of the correcting couple and the value of the righting moment.

The forward plane has an angle of incidence of eight degrees and that of the rear plane is five degrees, or three degrees less than that of the forward plane. The profile of the forward plane is that of Eiffel's No. 8, which gives, at eight degrees, a lift of $K'_y = 0.058$, while the rear plane, conforming with Eiffel's No. 13 *bis* (Blériot, No. XI *bis*) gives, at five degrees, a lift of $K_y = 0.041$ (about). On account of the difference in area of the forward and rear surfaces the total lift of the forward surface varies less rapidly than that of the rear surface when the angle of incidence changes.

If then, at the instant when the two lifts, $R_y = K_y S$, and $R_y' = K_y' S'$, are in balance with respect to the center of gravity, the machine rears under the influence of a perturbing force, the lifting force changes more quickly aft than forward, forming a couple tending to raise the tail or to restore equilibrium.

In case of a sudden dip, caused by external perturbing forces, the difference in the power of the two lifts is reversed; that under the forward plane becomes preponderant and rights the machine.

The two wings of the forward plane can be moved independently of each other through limited angles around a horizontal axis, by means of two levers in the hands of the pilot. These levers are parallel and abut against a small transverse bar which marks the position of normal or horizontal flight.

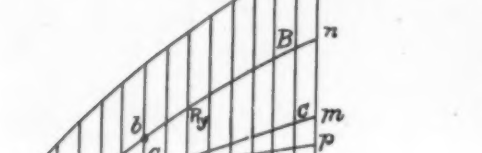


Fig. 1.—Variation of Sustentation of Wings, No. 8 and No. 13 *bis*., in Function of the Angles of Incidence. *A*, Curve of Total Sustentation $R_y + R_x$. R_y, Curve of Sustentation of Rear Wing (Type No. 13 *bis*., Eiffel). R'_y, Curve of Sustentation of Forward Wing (Type No. 8 Eiffel).

Lateral stability is controlled by working the wings of the front plane, and, just as in other machines, it is controlled by moving the ailerons. The machine can be made to ascend either by moving both forward wings together or by increasing the power of the motor. It is made to descend by decreasing the number of revolutions, or the power of the motor.

There are two small vertical rudders for steering, one at each extremity of the rear plane, and they are worked alternately by the feet. Turning is accomplished by checking or moving one of the vertical rudders toward the axial line. These rudders offer also a means of checking the speed on landing, by turning both sharply inward. They also offer a means of regulating the slope or angle of inclination for descent, by reducing the speed, and are thus another guarantee of safety. A drift plane placed in the rear above the body checks whatever tendency there may be to roll.

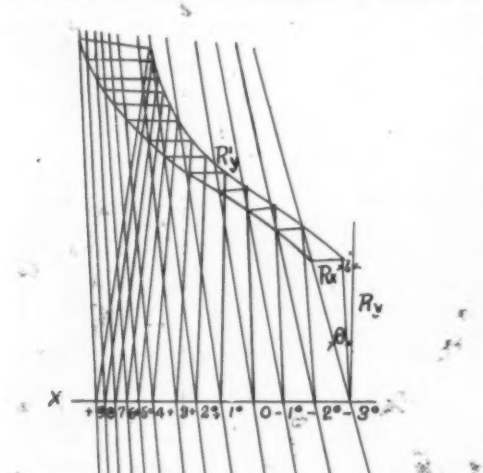


Fig. 3.—Curves of Stability of the Model, Showing the Displacements of the Center of Sustentation With the Variation of the General Incidence and Also the Different Values of R_x, R_y and θ. *A B* indicates the Axis Line of the Propeller.

The motor is installed near the middle of the body, the propeller being placed in the rear at the end of the body.

There is also an articulated landing gear (chassis) supported on wheels and furnished with an oleo-pneumatic brake, the cylinder of which is placed horizontally under the body. Revolution of the wheels, on landing, moves the piston of the brake, and this throws down a skid or drag, thus checking gradually but quickly the speed over the earth.

After the principle of this machine was laid down, a reduced model, one tenth the size, was tested at the Eiffel laboratory, suspended in different positions corresponding to different angles of incidence. These tests demonstrated that inherent stability was assured. Furthermore, the laboratory investigations of this model permitted a vigorous determination of all conditions of equilibrium connected with the circumstances of flight and to trace the diagrams shown in Figs. 1, 2 and 3.

Fig. 1 shows the two curves R_y and R'_y indicating the simultaneous lift of each surface in all positions of inclination. The sum of the ordinates $R_y + R'_y$ gives the curve *A* which represents the total lift.

The two curves first mentioned intersect at a point which is outside of practical limits of inclination and, by reason of the choice of profiles, the curve R'_y, which corresponds to the forward plane surface, is, on leaving this point of intersection for a dip, above the curve R_y, which represents the rear surface. We see also that R_y increases more rapidly than R'_y on rearing and decreases more rapidly on dipping, as previously indicated.

If it be desired that the normal flight occur at a given angle of incidence, it is evidently necessary that, in this position of flight (at the ordinate 8 to 5 degrees, for example), the center of gravity be located at such a position on the ordinate as to make the two parts of the ordinate inversely proportional to the two lifts. The curve *C* gives precisely that proportional division of all the ordinates; it represents, in a way, the locus of the points of application of the resultant forces tending to right the machine when out of balance. For a flight to take place under incidences of 5 degrees and 8 degrees, for the rear and forward plane surfaces, respectively, we can say that the point of the curve R'_y which is situated on the ordinate 5 to 8 degrees defines the position of the center of gravity, but that it is not displaced if the angles of incidence become temporarily 13 to 16 degrees, for example. The actual position of the center of gravity always dividing the axis in the ratio $\frac{Ga}{Gb}$, we can represent the locus of its various positions by the curve passing through *G* and *m* if $\frac{mc}{mn} = \frac{Ga}{Gb}$. The direction of the couple that arises by oscillation around the center of gravity *G* is represented by *m p* on the ordinate 13 to 16 degrees and by *p'm'* on the ordinate 0 to 3 degrees, changing sign on opposite sides of *G*.

Fig. 2 sums up the practical tests of the reduced model in the laboratory tunnel and gives the values of the total lift R_y, of the resistance R_x, and of the proportion

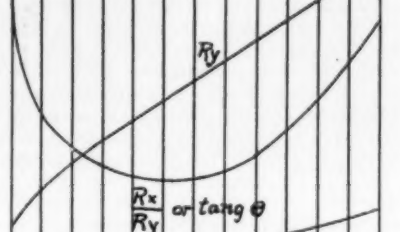


Fig. 2.—Variation of the Two Components R_x and R_y of the Resistance Shown by the Model Tested at the Laboratory of M. Eiffel.

$\frac{R_x}{R_y} = \tan \theta$, indicating the angle θ made by the resultants of the two components of the air resistance with the vertical.

The angles of incidence shown as abscissæ are those of the fuselage—in other words, they represent the angles of inclination of the base line. This base line, in normal flight, is horizontal and forms an angle of 2 degrees with the axis of the body.

Fig. 3 represents the actual position of the successive pressures for inclinations between —3 and + 9 degrees, each being the resultant of R_y with R_x and passing through the point of suspension of the model when these values were obtained. These different positions of the pressure would suffice to determine a metacentric curve, but this would fall outside the limits of the diagram and, besides, would be useless to consider.

The prolongation of the oblique pressures to the axis permits of measuring the distance to the center of gravity *G*, i. e., the arm of the lever of the correcting couple, which is *nil* when the pressure passes through the center of gravity. The axis of the body then makes with the horizon an angle of + 2 degrees which corresponds to the incidences of + 8 and + 5 degrees of the two surfaces conformably to the conditions imposed.

Finally, the different elements of the diagram permit also of calculating the speed for which the pressure equals the weight and the motive power capable of overcoming the resistance R_x, thus giving complete characteristics of the aeroplane.

Fig. 4 shows the characteristic profiles of the two surfaces as represented in M. Eiffel's second volume.

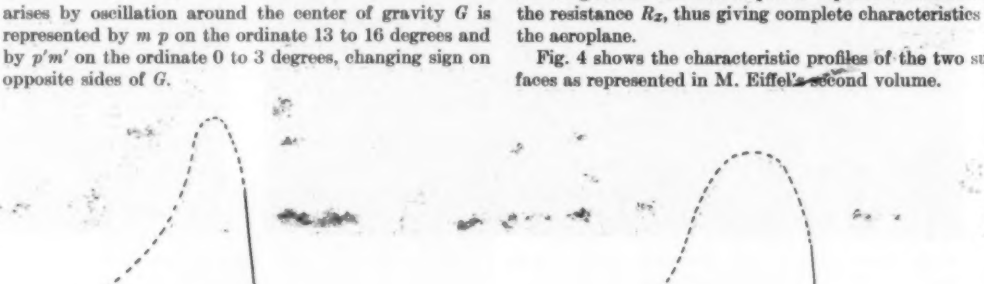


Fig. 4.—Characteristic Profiles of Autostable Wings. (From Eiffel's 2nd Volume.)

Our National Forests

Their Value, Management and Needs

VALUE OF THE RESOURCE.

THE National Forests contain nearly one fifth of the standing timber of the United States, protect the headwaters of every important Western river, and for a part of each year support one half the sheep and nearly one tenth of the cattle on the Western range. Upon their wise use and the perpetuation of their timber resource largely depends the welfare of manufacturing, mining, farming, trading, and transportation interests, and of the lumber-using and wood-consuming public. With effective water conservation is bound up the welfare of irrigation farming in the arid and semi-arid States, made possible by the investment of over $300,000,000; of water-power development, which in 1908 had reached a total development worth annually over $30,000,000 per year; and of navigation, because of the effect both of soil wash upon rivers and harbors and of the regulative influence exercised by forests upon the seasonal volume of stream discharge. With National Forest range control is bound up the welfare not only of the stockmen whose use of open winter range is conditioned upon summer feed for their sheep and cattle in the mountains, but also the welfare of the farmers whose forage and grain crops can often go to market profitably only in the form of beef and mutton, and the welfare of the meat-eating public.

The 600,000,000,000 board feet of merchandise timber on the National Forests is worth, if valued at only $1 per thousand on the stump, $600,000,000, or more than half the National Debt; while the land itself is capable of growing not less than 4,000,000,000 feet of timber annually to replace what is cut. The annual product of that part of the live stock industry which uses the National Forests has a market value to the growers of about $25,000,000. The protection given to water by the maintenance of the forests has a value literally beyond estimate.

POLICY OF MANAGEMENT.

The National Forests are administered, at a present cost to the Government of about $5,000,000 gross or $3,000,000 net, with a view to:

1. Protection of both timber and land as valuable public property. The timber is protected principally against fire, by a field force of about 2,500 men distributed over an area greater than all the United States north of the Potomac and east of the Ohio River; which is an

average of only one man to 94 square miles. The land is protected against loss of its productive power through the effects of fire and overgrazing. Fire always impoverishes, and sometimes entirely destroys the soil, either by burning it down to the bare rocks or by causing it to wash away, while overgrazing not only reduces the production of forage and timber, but also increases erosion.

2. Increased yield of water, wood, and forage. Just as good farming means building up the productive capacity of the land, not merely preventing it from running down, so good forestry means improvement as well as protection. The yield of the forests is increased partly through intelligent control of use (comparable to scientific cultural methods on the farm), partly through outlays for such purposes as reforestation and range improvement. Therefore the $3,000,000 net outlay upon the National Forests, besides paying for protection and meeting the cost of current business, includes a considerable betterment outlay, part of which is for increased equipment.

3. Permanent improvement of forests. Economical and efficient protection as well as general use of the forests call for opening them up by systems of roads, trails, and bridges; the clearing of fire lines and building of lookout towers; for ranger stations, and pastures, so that men and horses may be most advantageously distributed, and for telephone lines and connections. For these improvements and equipments Congress from 1909 to 1912, inclusive, specifically appropriated $1,975,000 in the aggregate, while the estimated value on June 30th, 1912, of all improvements was $2,791,000, considerable improvement work having been accomplished prior to 1909 by the expenditure of general funds, and the work of rangers and other forest officers, and through co-operation with counties, or other civil divisions, corporations and individuals. At present there are less than 1½ miles of trail and 1½ miles of telephone to each township of 36 square miles. At least six times as much is needed for a primary system to safeguard the forests.

4. Increase of all kinds of use. The forests are studied as public resources, to be worked up to the limit of their permanent capacity. Provision is made for every form of use possible without a more than countervailing curtailment of other use. In other words, the purpose is to make the forests serve the interests of the public which owns them, in the largest measure and in every way possible. This is evident by the fact that the number of transactions pertaining to profitable use of the forests in 1912 aggregated over 80,000.

RESULTS.

With a yearly expenditure for all purposes, including permanent improvements and reforestation, of less than 3 cents per acre of land, the following results have been secured:

1. The maintenance of organized protection against fire, which last year kept down the merchantable loss to about one fortieth of 1 per cent of the total, stand held over 60 per cent of the fires reported within an area of five acres or less, and contributed materially to the protection of private property within and near the forests.

2. The harvesting at the present time from the forests of about 500,000,000 board feet of timber yearly, cut under Government supervision by methods which not only insure renewal of the timber crop, but lessen the fire hazard and improve the remaining stand.

3. Additional reforestation, through natural reseeding accompanied by fire protection, of some 150,000 acres annually of denuded land and artificial reforesting operations through planting and sowing on nearly 25,000 acres last year.

4. Water conservation throughout the mountain regions of the West, including protection of the purity and sustained supply of many cities and towns.

5. Better utilization of the forage crop through constructive methods of range management. Nearly 1½ million cattle and horses and 7½ million sheep and goats use the range annually under a carefully devised system which assigns to each class of stock the range areas best adapted to its use, prevents over-grazing, avoids unnecessary loss of forage through trampling, and has eliminated the old scramble of stockmen in a free-for-all race for grass, with all the resulting wastefulness and uncertainties. Thus in conserving the range there has been brought about also:

(*a*) Greater stability and improved conditions for the stock industry, which experiences a smaller percentage of losses and ends the season with better-conditioned animals than in the old days.

(*b*) Increasing forage production. On a majority of the forests the carrying capacity of the range is rising.

The increasing occupancy of National Forest lands under permits covering the widest variety of uses, from summer camps and cottages to power plants and from pastures and apiaries to hotels, slaughter houses, stores and schools.

IMMEDIATE NEEDS.

The most urgent needs of the National Forest work are:

1. Liberal provision for permanent improvements, which enormously increase the efficiency of the protective force as well as open the forests to greater use. Chief Forester Graves estimates that the total costs of the completed protective system of trails and telephone lines, now planned, will equal about 1 per cent of the present value of merchantable timber in the forests; and he has asked for one tenth of this total annually for ten years, or $500,000 a year.

2. More men for patrol. The fire loss is still too high. From the standpoint of the value of the property (both public and private) exposed to destruction, one man to 94 square miles is not sufficient and the 3 cents available to the acre per year for all purposes is too little to spend.

3. Larger resources for conducting the investigations which underlie scientific use of the forest and range. Just as scientific agriculture is founded on the work of the experiment stations and the investigations of men who have studied crop production and animal husbandry from every side, so the best use of the soil for growing timber and forage and regulating stream flow must await the gathering of fuller knowledge than we yet have concerning the natural forces through whose control man may mold nature to the best service of his needs.

The great fight in the near future wil lbe to hold what conservation has already won. This fight will center around the National Forests and all they contain, but it is exceedingly likely that it will also involve the attempt to cede not only the National Forests but the whole Public Domain to the Western States. The movement to accomplish this result is organized, alert and active. Its avowed object is to turn the National Forests over to the States. The movement, which has been brewing for many years, first assumed important proportions four years ago, when State versus Federal control of the natural resources was made a plank in many State platforms. Since then the movement has grown with great rapidity. During the present Congress, fourteen bills have been introduced which are aimed in one way or another to turn over to the States natural resources now under Federal control. The policy of these bills is being advocated openly and strongly by many members in Congress. If this movement is not intelligently opposed it may win. If it is fought vigorously and wisely it will not win. But to make the victory complete and lasting, public sentiment must be fully informed as to the real issues at stake.

There are two great reasons why the National Forests should not be turned over to the Western States. One reason is that such a step would involve waste of money and effort, and would impair the usefulness of the National Forests to the people. The other reason is that the States are not ready for this task. So far as they have performed a similar task in the past they have done it in the main incompetently, or what is much more serious, not with an eye single to the public interest.

Ownership or control of the National Forests by the Western States would entail the creation of many Forest Services instead of one. Few States have more than the mere beginnings of an efficient forest organization, and still fewer have an adequate machinery for getting and retaining, regardless of political considerations, efficient men for the work. But beyond all that is the fact that these National Forests are a National resource on which depends the prosperity not of any one section or part of the people or of the country, but of the whole people and of the whole country. To develop their fullest usefulness to the whole people and to the whole country calls for their administration under National policies from the National point of view. Streams and forests, mineral veins and measures, the range, and the public land itself, do not stop at State lines, nor does the need for their best use in the interest of all the people stop at State lines. Could our cities be administered for the benefit of those who live within them, if there were a mayor in each ward, all acting independently of each other? Could the railroads serve the public efficiently if there were a president of each division, each without relation to the other? No more can the National Forests be handled, developed, and used in the best interest of all the people to whom they belong if they are turned over to the Western States.

At present the forests are administered for the welfare of the whole nation by a central office which sets the policy and the pace, and by local organizations which handle the work on the ground. If the National Forests were given to the Western States, their administration would be no more intelligently local than at present, because they are already handled by Western men in each forest and in each district office. The cession would simply mean that the central control which now keeps each National Forest doing its share in public usefulness, and working independently with each other National Forest, would disappear. There is no good reason for such action.

There are men whose conviction it is that the National Forests could be handled best by the Western States. But it is also true, as has been shown in the administration of their public lands by many States, that such proposed cession would increase many times the danger that National Forest resources would pass into unregulated private ownership, and in the case of certain States now dominated by private interests, that result would be certain.

So far, the men who stand behind this movement to turn the National Forests over to the States are, with rare exceptions, men who have the welfare of the special interests first in mind.

Power from Waste Fuel

Prof. Lewes states in his recent book on the "Carbonization of Coal" that his investigation of the coalite process made it abundantly clear that ammonia is a low-temperature product of the distillation of coal, and he calls attention to certain experiments made by Tervet in 1883, which indicate high ammonia yields from incandescent coke through which a stream of hydrogen is passed. He asserts, moreover, that low heats in carbonization favor the retention of the nitrogen by the coke. It will probably be within the mark if the yield of sulphate of ammonia from the coke is taken at 45 pounds, or a total of, say, 65 pounds from the coal and coke. If the 5,000 cubic feet of gas from the retorts is used with the producer gas for the generation of electricity it would yield a further amount of current equivalent to 227 kilowatt hours, say, a total from the ton of coal of 1,527 kilowatt hours,worth, at 1 cent per kilowatt hour, $15.27. There would also be a certain proportion of heavy and light oils condensed from the producer gas. The steam for the producer plant would be raised by means of the exhaust gases from the engines, and therefore no coal would be needed for this purpose.

In view of the conservation of our coal supplies, the possibility of the home production of oil for use in motor-cars and in the Navy, the provision of valuable manures for agriculture, and the prevention of smoke, these figures would appear to demand very careful consideration. It cannot be said that a high price has been placed on the electrical current, for it has been shown that with electricity at 1 cent per B.T.U. the electric light would necessarily be cheaper than gas, and large distributing companies could probably make a handsome profit if they could purchase their electricity at the above figure.

FRENCH ESTIMATE OF PROFITS.

A recent French writer has shown that one metric ton of coal used for steam raising could, if the whole of the steam were employed in a steam turbine of the best construction, generate 1,428 horse-power, but he contrasts this output with the utilization of the coal in a more rational fashion, and he gives a diagram to explain his arguments. Taking the same weight of coal, he estimates that it would yield in the retort 14,000 cubic feet of gas and 24.72 cubic feet of coke. This latter would in the gas-producer generate 23,000 cubic feet of air gas, together with the various residual products, including 121 pounds of tar and benzole and 100 pounds of sulphate of ammonia. From the 14,000 cubic feet of gas from the retorts he assumes that it would be possible by means of the gas-engine to obtain 800 horse-power, the tar and heavy oil would yield 85 horse-power, and the air gas from the producer is estimated to furnish 1,166 horse-power, so that by this treatment the coal is made to supply 2,051 horse-power, together with light oil and ammonia, instead of the 1,428 horse-power obtained by the steam turbine. In the case of the ordinary reciprocating engine the discrepancy is, of course, even greater.

In certain of the German and French collieries large quantities of very low-priced coal are now being used in order to generate electricity by means of the gas-engine, and the size of these engines is constantly on the increase. Power is also being obtained from coke breeze, and even from the locomotive refuse—that is, the combustible material blown from the bars of the engine fire-box. This waste product was at one time tipped to spoil in large quantities, and could be purchased at 18 shillings per truck load of ten tons, but it has now been found possible to employ it in producers which develop 1 horse-power hour from 1.75 pounds of the refuse. Some of the somewhat similar coke dust from the gasworks has been shown to possess a calorific value of 9,720 to 10,620 B.T.U. per pound.

Several French railway companies are now realizing a fair profit from the locomotive refuse which had formerly to be disposed of at a loss. This is accomplished by converting it into producer-gas for employment in the gas-engine on the system above described. Enough has been probably said to show that, by means of the electrical system of distribution, power may now be profitably obtained from many descriptions of cheap fuel formerly wasted, and that coal used on scientific lines can be made to furnish, in addition to power for electricity, many valuable by products.—*London Times.*

Static Damage to Filaments with Feather Duster.—According to the New York Electrical Testing Laboratories, it was found, in a school building where the filaments of the incandescent lamps were frequently broken and twisted through the side of the glass, that the damage was due to the cleaning of the lamps with a feather duster. When, in place of the duster a dampened cloth was used, the abnormal breakage of the filaments ceased.

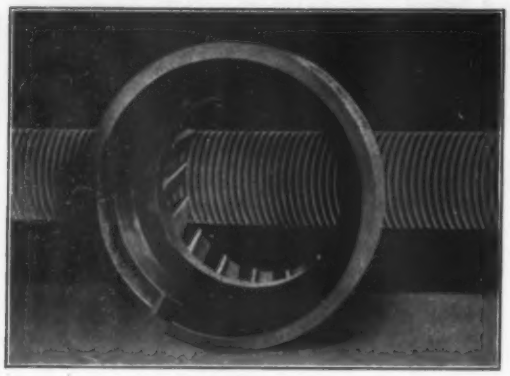


Fig. 1.—How the Teeth Are Cut.

Fig. 2.—The Circular Cut File.

Manufacturing the Circular Cut File*

By Chester L. Lucas†

Fig. 3.—Forging the Tang.

SINCE the days when primitive man used the file for sharpening his implements of field and war, the file has been one of the most common tools. As in many other commonplace things, however, no one seemed to see room for improvement until, in 1900, Alexis Vernaz, of Yverdon, Switzerland, was trying to devise a hand tool for cutting a lot of exceptionally hard castings. The Vixen file was the result of his efforts. His whereabouts is not known at present, but there is an Elliott Cresson medal waiting for him that was awarded by the Franklin Institute in 1909 for making the first radical improvement in files for generations. The essential points of the Vixen file are well described by a sentence from the patent specifications: "A file provided with teeth cut in the form of arcs, having their bases located rearwardly with respect to the cutting edge of the teeth."

Fig. 1 illustrates a Vixen file, in which it will be seen that the radical difference between it and the ordinary file lies in the shape of the teeth. The object of curving the teeth is to provide a shearing cut, and by reason of this shearing cut the file is self-clearing. The determination of the radii of the arcs of the cutting teeth of the various sizes of files was the result of experiments which indicate that the best cutting tooth is obtained by using a radius approximately the width of file being made. Teeth cut on smaller radii in proportion to the width of the file make it impossible to guide the file correctly, and teeth of much larger radii do not cut nor clear as easily. The teeth of Vixen files are milled with hollow cylindrical cutters. Several of these cutters are shown in Fig. 9. Of necessity, the cutter is slightly inclined to the face of the file while cutting the teeth, in order that the side of the cylindrical cutter not being used may clear the parts of the file not being cut. This condition is graphically shown in Fig. 1. The amount of this inclination varies from 2 to 4 degrees, depending on the different depths of cut. By thus inclining the cutter to the work and securing a rake to the teeth, an added quality is given to the tooth, enabling it to cut rapidly. The inclination of the axis of the cutter results in cutting the teeth slightly deeper at the center than at the edges, therefore, the face of the finished file is slightly lower in the center, the amount, however, is so small that it is practically imperceptible.

STEEL FOR VIXEN FILES.

The steel from which Vixen files are made is a Swedish chrome steel and is ordered on specification calling for chemical analysis as follows:

Carbon	1.20 to 1.35 per cent (1.25 per cent desired)
Chromium	0.40 to 0.60 per cent (0.50 per cent desired)
Manganese	not to exceed 0.40 per cent
Silicon	not to exceed 0.30 per cent
Phosphorus	not to exceed 0.03 per cent
Sulphur	not to exceed 0.03 per cent

The hardness, according to the Brinell hardness scale, should be from 130 to 170, a hardness of 150 being desired.

OPERATIONS IN MAKING THE FILE.

The first operation in the making of the file consists in the shearing of the bar stock to length. This is an ordinary operation and is performed upon a shearing press of the usual type. From the shearing press the short lengths of steel go to the tanging hammer where the tangs of the files are forged in the manner illustrated in Fig. 3. The dies, and the beginning of the tanging operation are here illustrated. A helper hands the file blank, one end of which has been heated to a forging heat, to the operator of the hammer in which the tangs are forged. The blank *A* is held in special tongs *B*. The first part of the tanging operation consists in "nicking"

Fig. 4.—The Cold-straightening Operation.

the end of the file blank between the two half rounded projections *E* at the front of the dies *C* and *D*, leaving the file blank in the condition shown. After this blow the operator shifts the file blank to the middle section *F* of the dies which have beveled faces corresponding with the taper of the tang. By rapidly turning the blank after each blow, the metal beyond the nicked portion of the blank is drawn out to approximately the shape of the finished tang, after which one or two blows are struck on the finishing faces *G* of the die to complete the tang. It is an almost incredible fact that the tang of an 8-inch file is forged in from ten to fifteen seconds from the time it is taken from the fire.

Following the tanging operation, the trade-mark impression is stamped upon the shank of the file, after which the blanks are annealed by being heated in large quantities in iron boxes and allowed to cool very gradually. The annealing operation decarbonizes the exterior surface of the steel, and before cutting the teeth it is important that this inferior surface of the stock be faced off. This operation, called stripping, is common in making files of all kinds, the metal being removed on large broad-faced grindstones, 6 feet in diameter. The files are held by the tangs on the plate shown at *A* in the illustration Fig. 5, which is dropped into position against the wheel and clamped by bar *B*, after which the holding plate and files are reciprocated in a vertical line against the face of the wheel *C*, at the same time being flooded with water and fed gradually against the wheel. By this means, 1/64 inch is removed from each side of the file-blanks, leaving them perfectly flat and ready for the cutting of the teeth.

CUTTING THE TEETH.

The most interesting operation in connection with the making of the Vixen file is the cutting of the teeth. The machines for cutting the teeth are operated in groups of eight, being driven from lineshafting at the rear of the rows of machines. Two of these groups of machines are shown in Fig. 6. The machine consists essentially of a spindle which carries the cylindrical cutter and a table which supports the file blank in a plane at right angles to that of the cutter spindle. As the cutter revolves, it is fed forward to the file blank, withdrawn, the file holding table moved forward the distance of one tooth and the cutter spindle brought forward again. Thus, the teeth are cut one at a time and the machine is automatically stopped after the last cut. Referring to Fig. 7, the cutter spindle, its method of feeding and the cross feed of the work table, may be seen. The cutter spindle shown at *A* is driven by bevel gearing from the extreme right hand end of the machine. By means of gear *B* in mesh with gear *C* operating on a wormshaft, the worm *D* engages a worm-wheel, not shown, which causes cam *E* to turn against yoke *F*. Yoke *F* is attached to collar *G*, and thus as the high part of the cam is reached, the cutter is fed forward to its deepest position with respect to the file and, of course, returned when the low part of the cam is reached. The double spring box *H* constitutes a means for insuring the feeding of the cutter to the proper depth of the tooth in each instance; the springs within the barrels overcoming any tendency for uneven feeding of the spindle caused by chips lodging upon the cam or from other sources.

The cutters themselves are made of Rex high-speed steel. Four of these cutters are shown in Fig. 9, and, as may be seen, they are milled very deep between the teeth, which allows them to clear themselves of chips rapidly and provides for many sharpenings before they are worn out. The cutting faces are ground to an included angle of 60 degrees and the cutter is held to the end of the spindle by a flanged sleeve *I*, shown in Fig. 7, which is tightened by a spanner wrench holding the cutter

* Reproduced from *Machinery*.
† Associate Editor of *Machinery*.

Fig. 5.—Grinding the Sides.

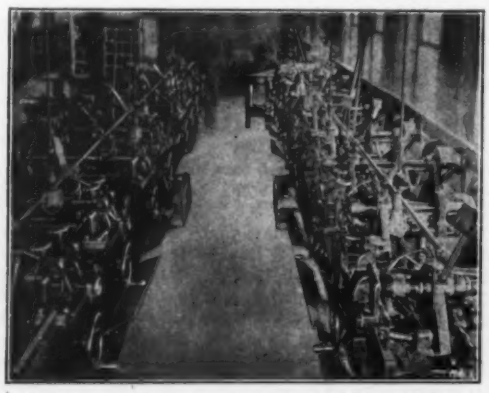


Fig. 6.—Two Groups of the Tooth-milling Machines.

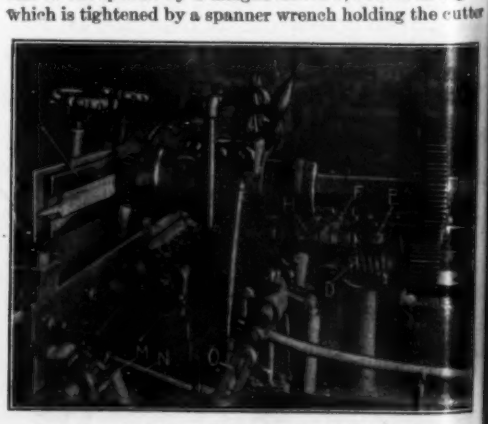


Fig. 7.—Details of Machine for Milling Teeth.

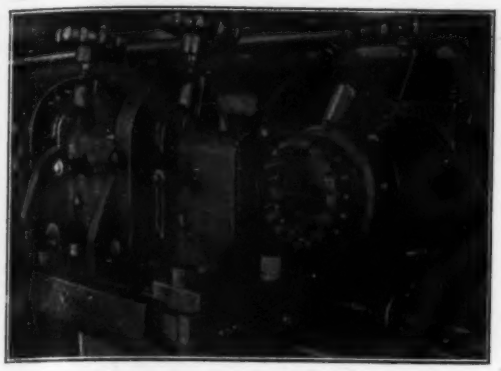


Fig. 8.—Close Range View of Cutting Head.

Fig. 9.—Four of the Cutters.

Fig. 10.—Preparing the Files for Heating in Lead.

securely in place. The illustration Fig. 7 also shows the method in which the files are held for cutting, consisting of the two clamping screws *J* which operate against jaw *K* of the vise. For varying the depth of the tooth, handwheel *L* is used, thereby bringing the work table nearer to or farther from the cutter. The number of teeth cut per inch varies from 6 2/3 to 16, and for spacing the teeth there is a ratchet and pawl upon the end of the feed shaft. This pawl, shown at *M* in the illustration Fig. 7, is operated by a lever *N* which, in turn, is reciprocated by the arm *O*. Another view of this machine is shown in Fig. 8 which more clearly shows the cutter and its relation to the file blank.

The widths of the files vary from 7/8 inch to 1 3/4 inch. There are, on each side, from 90 to 250 teeth, varying, of course, with the pitch and length of the file. It takes twenty-five minutes to cut the teeth in one side of an ordinary 12-inch Vixen file, as compared with one minute for cutting the teeth on one side of an ordinary commercial 12-inch file. Hence it is apparent that the manufacturing cost of a Vixen file is comparatively high.

HARDENING.

Previous to heating the files for hardening, they are treated with a charcoal and oil preparation to prevent the lead used in the heating from clinging to the teeth and thus interfering with the hardening. The files are brushed with this solution and placed against racks of steam pipes as shown in Fig. 10, to bake the coating on before the files are placed in the lead pot.

The molten lead in which the files are heated is kept at a temperature of 1,400 degrees, its condition being indicated by a Bristol pyrometer. Several files are kept heating in the lead pot, being immersed to the tangs. A bar across the top of the lead pot holds the files beneath the surface of the molten lead so that they may be heated slowly and evenly. A file is taken from the lead pot by the hardener, and before being quenched in the brine solution in which the files are hardened, the red hot file is rapidly straightened across lead blocks with a wooden faced hammer. This operation, which is shown in Fig. 12, is necessary on account of the strains set up in the steel by the milling of the teeth. After straightening, which takes but a few seconds, the file is plunged straight down into the brine and moved rapidly up and down until the "singing" has nearly ceased. The file is then quickly removed, sighted, and again straightened after the manner shown in Fig. 4. For this purpose the file is clasped in an iron holder, *A*, after sighting, and placed with the high side down against the wooden bar *B*, the tip end of the file being caught under bar *C*. Pressure is then applied to straighten the file and cold water splashed upon the upper side to bring the file back to a straight condition. This operation of straightening requires a great deal of judgment, for, if the file is kept in the hardening tank a few seconds too long, it will break when pressure is applied for straightening, and on the other hand if removed too quickly, the temper of the file will be impaired.

SHARPENING THE FILES.

From the hardening department the files go directly to the sharpening machines. Unlike the sharpening of most tools, files are sharpened by being passed over jets of steam which are mixed with a cutting paste made with a fine mineral abrasive powder. The sharpening machine shown in Fig. 13 is equipped with three nozzles which are shown being used in the operation of sharpening Vixen files. The base of the machine contains the sharpening paste which is led to the nozzles of the steam pipes and thus is propelled against the sides of the file when it is moved backward and forward over the nozzle. A spool, shown just above the nozzle, is used to keep the file at the proper distance from the nozzle. In addition to removing all dirt and scale from the files, this operation sharpens the file by cutting away a slight amount from all parts of the file which it strikes. The files are held by the tangs and in passing over the nozzles, the abrasive material strikes the teeth from the back. If the operation were reversed and the files fed in from the

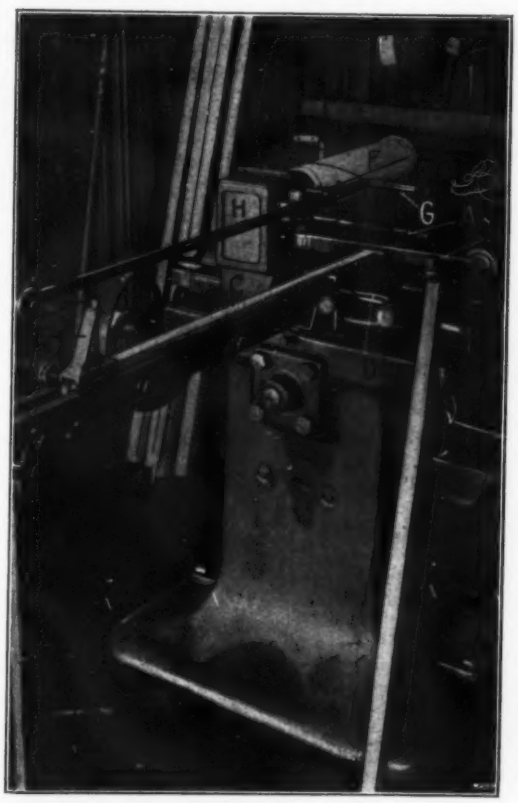


Fig. 11.—Herbert File Testing Machine.

points, the sharpness of the teeth would be removed and the files dulled instead of sharpened. For testing the sharpening, "provers" are used. These provers consist of short pieces of soft steel which are drawn over the file by hand. Even to those unaccustomed to this work, the prover indicates the fact that the file has been really sharpened, and to the sharpener the prover reveals any sections of the file which are not quite up to standard sharpness. Lime is added to the special sharpening compound to prevent the files from rusting after they leave the sharpening machine. The final operation consists in cleaning out the file under a jet of live steam, and after oiling, the files are ready for use.

TESTING FILES ON THE HERBERT FILE TESTING MACHINE.

A Herbert file testing machine, shown in Fig. 11, the working parts of which are shown in detail in Fig. 14, forms the only practical method of testing the cutting and enduring qualities of the file. Briefly stated, the machine consists of a reciprocating file holder *A* in which the file *B* is held, backed up by suitable supports. The file is reciprocated across the end of the square test bar *C* at the rate of 50 strokes per minute. On the return stroke, the bar is withdrawn slightly by means of arm *D*. The forward feeding of the bar is accomplished by means of a 30-pound weight which is attached to the bar at the front of the machine by a chain running over a pulley. The rate of forward travel of the bar is recorded on the chart *F*, by the pencil held in the holder *G*. By means of clockwork within the case *H*, the chart cylinder is turned slowly, with the result that a curve is traced upon the chart which indicates the cutting efficiency of the file tested.

Phosphorescent Plants

By Prof. F. Cavers, D.Sc., F.L.S.

AMONG animals, phosphorescence is shown chiefly by various jellyfish, starfish, molluscs, and worms living in the sea. It is much more limited among land animals, insects affording the best-known examples—such as the glow-worm, which is the larva of a beetle. In many cases, perhaps in all, the phosphorescence is due to the oxidation of some phosphorus-containing substance in the animal's body.

Many plants have been described as phosphorescent or luminous; but it would appear that under this heading there are included various phenomena due to widely different causes. For instance, light is occasionally emitted by flowers on sultry nights; but it is now known that this is not due to luminosity of the plant itself. In some cases it is an electrical phenomenon comparable with "St. Elmo's fire"—a faint flame or glow seen at the tips of masts, trees, etc., in thundery weather, and due to the dissipation of atmospheric electricity in the form of a brush discharge. In other cases it is attributable to the presence of small phosphorescent insects which had been overlooked by earlier writers on "luminous flowers."

So far as plants are concerned, phosphorescence, in the strict sense, is narrowed down to the remarkable luminosity shown by certain bacteria and fungi. By isolating the bacteria—perfectly harmless kinds—which cause the phosphorescence of meat and fish, and cultivating them in nutrient jelly in a tube or flask, we can obtain a "bacterial lamp" and take excellent photographs in a room illuminated only by this "lamp." By making a large enough culture, one gets in this way a serviceable "living lantern," which may be used for a photographic dark-room, or as a night-light, and by which one can read one's watch or a book and distinguish objects several yards distant.—*English Mechanic and World of Science.*

Fig. 12.—Straightening Hot Files.

Fig. 13.—Sharpening the Files.

Fig. 14.—Details of the File Testing Machine

The Manufacture of Chemically Pure Acids*

Some of the Problems Encountered

By J. T. Baker

THE manufacture of chemically pure acids, hydrochloric, nitric, and sulphuric, is a subject concerning which very little if any literature is to be found. The reason for this is mainly that the manufacture of acids which will pass to-day as chemically pure is limited to comparatively recent years and the methods of manufacture have not yet found their way into chemical publications and text-books.

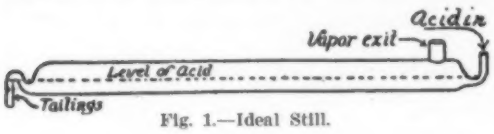


Fig. 1.—Ideal Still.

Twenty-five or thirty years ago the yearly production of chemically pure acids probably did not exceed one month's production at the present time, and owing to the enlarged field of analytical chemistry, the demand is constantly increasing. The manufacture has now reached a volume which entitles it to be classed as one of the large industries of the country and there are several manufacturing plants devoted in part, if not altogether, to this particular branch of chemical industry.

As a result of the growth of the business, manufacturers have been stimulated, if not obliged by reasons of competition, to devise improved methods of manufacture, in consequence of which the cost of production has been materially reduced and the market prices have fallen during the period mentioned from 50 to 85 per cent. In this connection it is interesting to note some of the improvements which have been made, and the ingenuity which has been displayed in overcoming some of the almost insurmountable difficulties.

The improvements referred to and to be herein described relate only to the methods of purifying so-called commercial-grade or crude acids and not to the actual manufacture of the acid itself, the latter being made by the usual methods more or less familiar to every student of industrial chemistry.

There is doubtless plenty of literature on the chemistry of making pure acids, but the chemistry is generally the simplest part of the problems of industrial chemistry, particularly when working on a large scale, for the greatest problems encountered are generally the mechanical details and cost of production.

It is only within the last score of years that the industry has advanced beyond the laboratory scale both in its methods as well as in the volume of its output. For many years the distillation of the crude acid was performed in glass retorts or flasks of 2 or 3 gallons capacity with small Liebig condensers in practically the same manner that distillations are performed in a college laboratory, only on a larger scale, and the amount of labor involved, together with the loss from breakage, made the cost of production not only high but uncertain. It was an interesting sight to see a battery of, say, twenty or thirty retorts side by side on a long sand-bath, each one having a separate condenser with numerous water pipes and stop cocks, all boiling at once; but when one retort accidentally cracked, followed probably by half of the whole battery and the contents suddenly disappeared in a dense cloud through the ventilators of the roof, the sight was rather disheartening.

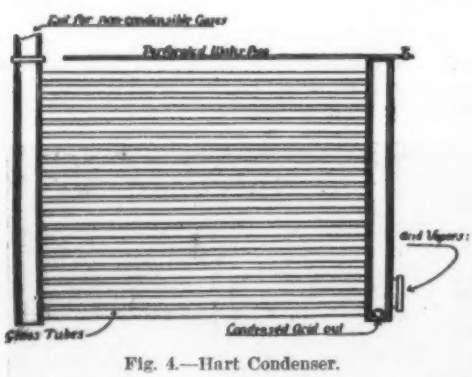


Fig. 4.—Hart Condenser.

The great problem was to devise a still of small capacity, but with a large heating surface which could be operated continuously by supplying crude acid as rapidly as the distillation proceeded, so that the quantity of acid in the still at any one time should never be very great and consequently little lost in case of breakage. Another advantage to be gained by such an arrangement would be the saving in time in getting the distillation started, as there would be but a small volume of liquid to be heated, while in a large still much time is lost in bringing the contents up to the boiling point, not to mention the loss of heat by radiation from the sides of a large vessel.

One great difficulty, however, connected with such still is the necessity of removing the impurities remaining in the tailings, which if allowed to become concentrated beyond a certain point will cause trouble by crystallizing out or spurting and being carried over into the distillate, while if an arrangement is made to draw off the tailings either continuously or intermittently, when using a still of the ordinary compact form, such a retort or flask, much good acid is liable to be wasted.

An ideal still that will solve the problem is illustrated in Fig. 1, and consists of a long glass tube with an opening at one end to admit fresh acid and one at the other end to draw off the tailings, the openings being in the form of traps to prevent the escape of the vapors, for which an exit is provided near the end at which the acid is admitted.

The still is kept about half-full and is heated from underneath along the entire length, the greatest heat being at the end near the exit of the tailings. The still being long and narrow there will be a constant movement of the contents toward the outlet, at which point the impurities will collect and will gradually be drawn off with the tailings at a rate that will avoid any trouble from crystallizing or spurting. Even if spurting should occur at this point it is so far from the exit for the vapors that there is no danger of any of the impurities being carried over into the distillate. With a constant supply of fresh acid entering the still to replace the contents as rapidly as it distills off, the distillation may be kept up indefinitely.

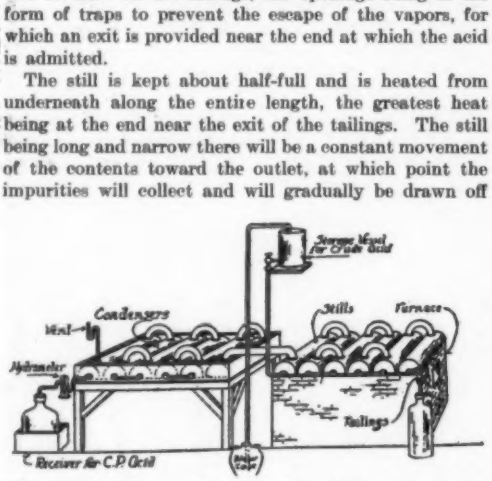


Fig. 3.—Distilling and Condensing System of J. T. Baker Chemical Company.

Such a still as the above, while perhaps practicable as a laboratory experiment, would not answer for operating on a large scale, because owing to the fragile nature of the material available for the purpose, it is not possible to construct such an apparatus that will be durable. The same principle involved has, however, been worked out successfully in various other ways and some of the apparatuses designed are protected by patents.

One of the original inventions was known as the Hart system and one which has proved to be as efficient as it was ingenious, is constructed of glass test tubes. The apparatus is illustrated in Fig. 2. A porcelain vessel in the form of a pipe, say, 4 feet long, 6 inches in diameter, is made with a row of openings close together along one side, into which glass tubes closed at one end and similar to a test tube, say, 18 inches long by 1½ inches diameter, are inserted and the joints made tight with rubber gaskets or asbestos fiber. The vessel is provided with a small opening at each end, one for the supply of fresh acid and the othe. for drawing off the tailings, and a larger opening on top to carry off the vapors. The vessel is supported on the brickwork of the furnace with the glass tubes depending downward and exposed to the direct heat of the fire.

A number of such apparatuses may be connected together and are placed on a level so that when the acid is admitted it will by seeking its level be at the same depth in each vessel and on a level with the outlet for the overflow of the tailings. The boiling takes place in the glass tubes, which afford large heating surface, and the distillation is exceedingly rapid, but may be easily controlled by regulating the temperature of the fire. The durability of the tubes depends upon the quality of the glass, but, as a rule, they stand the strain well and with proper care on the part of the operator the apparatus works quite satisfactorily. If occasionally a tube breaks, it can be replaced with comparatively little trouble without taking the apparatus apart, and the quantity of acid

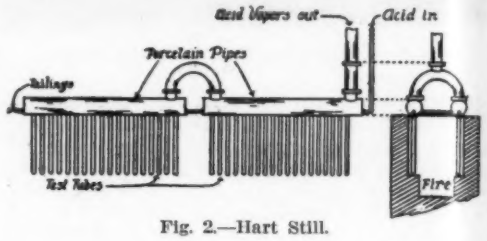


Fig. 2.—Hart Still.

lost is trifling because there is so little in the apparatus that can run out.

When working steadily the still is very efficient, a battery of four having a capacity of about 2,000 to 3,000 pounds of distillate per twenty-four hours, and if facilities are provided for supplying the acid to the stills by gravity so as to avoid unnecessary handling, the labor involved will be a comparatively small item of expense, while the loss in breakage and the cost of fuel is reduced to a minimum. This invention has been patented.

Another system of still constructed on the same principle of continuous operation and one which has been used for a number of years by the J. T. Baker Chemical Company is made entirely of porcelain, and having less joints there is less liability of leakage than in the apparatus above described, particularly where the joints must be made with asbestos, as in the case of nitric acid.

Under certain conditions porcelain will withstand the strain of great heat better than glass, and it has been found feasible to distill acid from porcelain vessels of considerable size without danger of breakage. An apparatus of this construction is illustrated in Fig. 3 (which, by the way, also illustrates a condensing system to be referred to later).

The vessels measure about 3 feet in length by 8 inches in width and are flat on the bottom in order to obtain a large heating surface. A number of vessels, say 10, are laid side by side on top of the furnace directly over the firebox and are connected together with small glass tubes near the bottom to conduct the acid through each vessel in succession and with porcelain goose-neck pipes for the passage of the vapors. The large extent of heating surface which the vessels afford makes the apparatus a very efficient still without forcing the fire and running the risk of cracking the porcelain, which owing to the size and nature of the ware has comparatively thick walls. In order to avoid condensation in the stills owing to the radiation of heat from the upper surface, the vessels are protected with a covering of asbestos. The joints are packed with rubber gaskets for hydrochloric acid and with pure asbestos fiber for nitric acid.

The crude acid is first elevated by air pressure from a blow case located where it can be filled conveniently to a storage vessel overhead from which it runs by gravity into the stills, the flow being regulated by a cock so that there will be a slight overflow of the tailings at the farther end of the system. The capacity of the still is about 2,500 pounds hydrochloric acid and 4,000 nitric acid per twenty-four hours' continuous running.

The condensation of acid vapors on a large scale was also a serious problem, for an efficient condensing system is absolutely essential to the successful working of any still. One of the first efficient condensers invented and patented was constructed of glass tubes and is illustrated in Fig. 4.

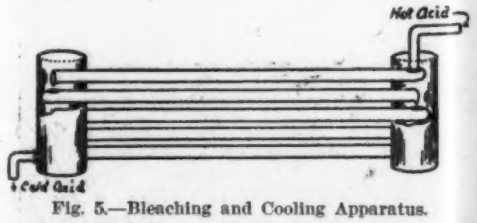


Fig. 5.—Bleaching and Cooling Apparatus.

It consists of a number of glass tubes 6 or 7 inches long by 1 inch diameter, and two so-called standpipes made of earthenware or porcelain (the latter especially for chemically pure acids), each about 4 feet long by 4 inches diameter, having a row of holes along one side as close together as possible and of a suitable size to receive the

* A paper presented before the American Institute of Chemical Engineers and published in abridged form in *Metallurgical and Chemical Engineering*. Abstracted from vol. iv. of The Transactions of the Institute.

glass tubes without binding. The standpipes are placed in an upright position and securely fastened in place, having the rows of holes facing each other and at a distance that will allow the tubes to enter far enough to enable the joints to be tightly packed. The acid vapors enter through an opening in the side of one of the stand-

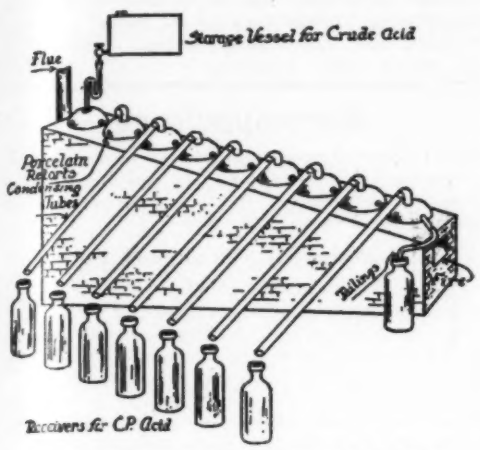


Fig. 6.—Continuous Still System of J. T. Baker Company.

pipes and is divided in its passage through the tubes in which the condensation is effected by trickling cold water on the surface of the tubes supplied from a perforated water pipe placed just above the topmost tube; the water trickles down over each tube in succession and becomes so hot before it reaches the bottom that much of it evaporates, thus increasing the efficiency of the condenser, and what does not evaporate is caught in a trough and carried off. The glass tubes are subjected to the extremes of temperatures where the cold water first strikes, but with a good quality of glass they stand the strain remarkably well, although breakage is not infrequent.

Condensation may also be effected without the use of water, as the heat radiates to considerable extent and causes a current of air which carries off the heat by contact. The cooling effect of the air is, of course, not as effective as that of water, but this deficiency may be made up by increasing the number of tubes. This also removes the danger of breakage experienced when using water, but, on the other hand, it increases the number of joints and the liability of loss from leakage when asbestos is used as a packing.

This condensing system, known as the Hart condenser, from the name of the inventor, has been in successful operation during a number of years as a condenser for both nitric and hydrochloric acids with certain modifications to suit the peculiarities of each acid, which will be referred to later.

The condensing system used by the J. T. Baker Chemical Company is made entirely of porcelain vessels and is illustrated in Fig. 3, previously referred to. The vessels are made practically the same as the porcelain vessels used as stills and are connected together in the same manner for the flow of the acid and the passage of the vapors. The condensation is effected by immersing the vessels in a bath of running water, the flow of the water being regulated so that the water surrounding the vessel into which the hot vapor from the still is entering will not be subjected to too great a change of temperature, otherwise breakage is liable to occur owing to the size of the vessel and the thickness of the walls. There are comparatively few joints to cause trouble from leakage, and they are easy to get at and keep tight. They are used for condensing both hydrochloric and nitric acids with some modifications to suit the peculiarities of each acid, the modus operandi of which will next be described.

The distillation and condensation of hydrochloric acid present difficulties which are peculiar to the acid itself and give rise to problems different from distillation processes in general. This is due to the fact that the concentrated acid does not distill at a uniform degree of strength nor at a uniform temperature. The strongest acid commences to distill at a very low temperature and gives off at first dense fumes of dry HCl gas which are uncondensable and must, therefore, be absorbed in water or in a weaker acid. As the distillation proceeds the temperature rises and the strength of the distillate as well as the remaining liquid decreases until both reach a strength of about 1.10 specific gravity, after which the strength of both, as well as the boiling point, remain constant.

The weaker grades of acid must, therefore, be again concentrated by saturation with the gas from subsequent distillations, and as the absorption gives rise to heat it becomes necessary to change the receivers frequently and allow them to cool in order that the final saturation may be made at a temperature low enough to insure the proper degree of strength. This was the old method of distilling, and, as it was necessary to use comparatively small stills, generally flasks of 2 or 3 gallons capacity, each one connected with a small Liebig condenser, and receivers of about the same capacity, the process involved much labor and was far from being economical, particularly when attempting to work on a large scale.

These difficulties were all successfully overcome when the continuously operating system was introduced. In this system the distillation of the strong and the weak acid takes place at the same time and the different strengths passing into the condenser together at once recombine, the gas being absorbed in the liquid simultaneously as the vapors condense, and the acid when it finally leaves the condenser will have the same strength as the acid entering the still. In the first vessel of the distilling system into which the fresh acid enters there is presumably a slight ebullition and dry gas given off, while from each succeeding vessel down to the last ones situated directly over the fire there is more or less moisture given off with a corresponding decrease in the strength of the tailings, the weakest being about 1.10 specific gravity.

In the first vessel of the condensing system into which the vapor enters (referring to the system illustrated in Fig. 3) only the weakest vapors condense, while owing to the temperature of the water surrounding the vessel being almost the same as that of the vapors, the gas passes on into the cooler vessels where it is absorbed by the liquid flowing slowly through them until in the last vessel, which is thoroughly cooled, the gas is all absorbed and the liquid at the same time saturated. The acid runs by gravity from the last vessel through a jar containing a small hydrometer and enables the operator to keep watch of the strength, which varies according to the proportion of tailings drawn off.

The distillate is usually a little stronger than the original acid owing to the removal of the tailings, for the reason that as the acid entering the still contains, say, 36 per cent HCl, the tailings contain only about 20 per cent, and the difference in the amount of HCl gas is absorbed in the distillate, thereby increasing the strength to that extent. Indeed, it is possible, by drawing the tailings off faster, to bring up the strength of an acid which is 2 or 3 degrees below saturation before distillation, but the method is not economical; the best results are obtained by using an acid, say, 1.18 specific gravity and drawing off enough tailings to bring it up to 1.19 specific gravity, which is the strength generally required by the trade. About 5 per cent in tailings is sufficient for this purpose and this amount is also sufficient to carry off the impurities fast enough when using ordinary commercial hydrochloric acid.

The impurities commonly found in the commercial

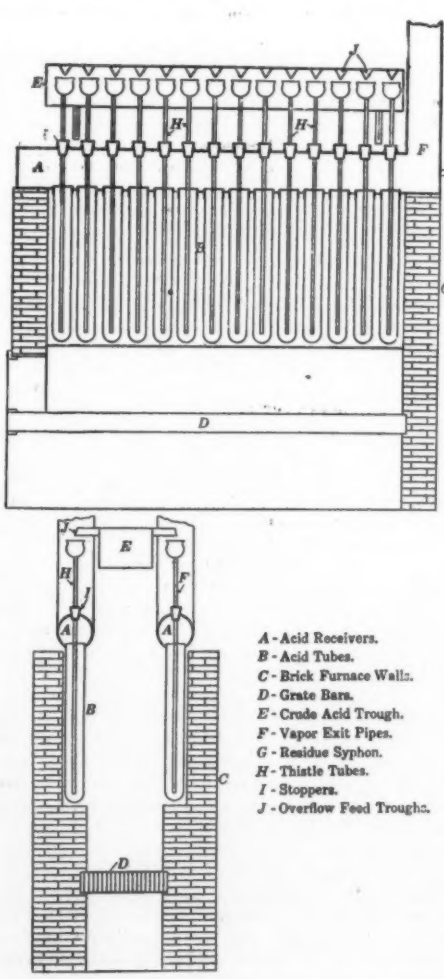

A - Acid Receivers.
B - Acid Tubes.
C - Brick Furnace Walls.
D - Grate Bars.
E - Crude Acid Trough.
F - Vapor Exit Pipes.
G - Residue Syphon.
H - Thistle Tubes.
I - Stoppers.
J - Overflow Feed Troughs.

Fig. 7.—Improved Apparatus for Distilling Apparatus.

acid are principally sulphuric acid, iron, sodium sulphate, arsenic, and sometimes sulphurous acid and free chlorine. Before distilling the acid sufficient chlorine is added to oxidize the H_2SO_3 to H_2SO_4, the excess of Cl being reduced by adding some reducing salt in solution. The non-volatile impurities remain in the tailings, and if

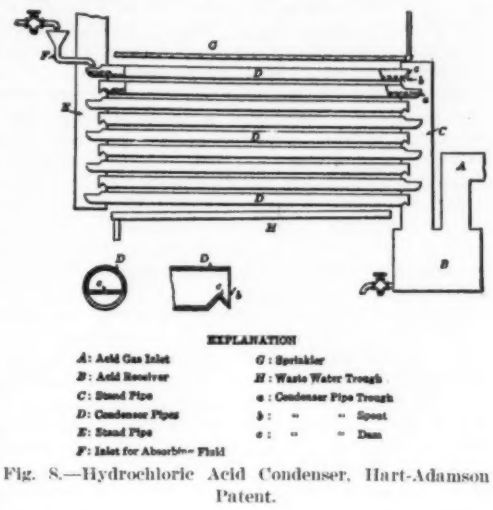


Fig. 8.—Hydrochloric Acid Condenser, Hart-Adamson Patent.

there is any spurting in the last vessel where they become concentrated or any volatilization of sulphuric acid at this point, these impurities will be retained in the other vessel without danger of being carried over into the distillate. Arsenic compounds being volatile are always found in the distillate, at least in traces, as it is impossible to obtain a crude acid made in the ordinary way from salt and sulphuric acid which does not contain some of this impurity.

An acid made synthetically from Cl and H as a by-product in the manufacture of caustic potash at Niagara Falls is free from arsenic and a chemically pure acid made by distilling this product after reducing the free Cl, which is always present in great excess, is strictly chemically pure. Organic matter is difficult to remove, as it appears to form a volatile organic chloride which distills over and gives a yellow color to the distillate, although it can then be reduced and removed by a second distillate.

Hydrochloric acid can also be condensed in a glass tube apparatus similar to one above described (Fig. 4) with some modifications; the tubes instead of being open at both ends are closed at one end and an opening made on the upper side when in a horizontal position placed directly under the open end of the tube above, which is provided with a lip, so that when arranged in alternate order the liquid will flow from the topmost tube through each tube in succession to the bottom. In this way the vapors which condense in the tubes follow a long and tortuous passage over which the gas passes and is gradually absorbed, while at the same time it is kept cool by water trickling over the outside. This arrangement is illustrated in Fig. 5, where it is described for another purpose. As an apparatus for absorbing gases it is covered by patents.

In the distillation of nitric acid difficulties are met which are easily overcome by using a continuously operating system similar to that used for hydrochloric acid with some modifications. The impurities commonly present in the crude acid are sulphuric acid and sodium sulphate from the materials used in its manufacture, chlorine and iodine present in the nitrate of soda and hyponitric acid due to a slight decomposition of the nitric acid in the process of manufacture.

The chlorine and hyponitric acid are volatile at a low temperature and will, therefore, be found in the first part of the distillate; the balance of the distillate will, however, contain some hyponitric due to a slight decomposition of the acid giving the distillate a slight yellow color, which can be removed by heating and subsequent exposure to air. In a continuously operating still, such as either of those above described, the volatile impurities are separated by conducting the vapors from the first vessel or two to a separate condenser from that in which the vapors from the remaining vessels are condensed, and instead of allowing the acid to leave the condenser cold, the latter is constructed so that the acid is drawn off hot in order to bleach it without subsequent heating. This is accomplished when using the glass tube condenser, by giving the tubes a slight inclination toward the standpipe into which the hot vapors are entering, and when using the porcelain vessel system, by inclining the bath and reversing the flow of the condensed acid back into the first vessel, in each case forming a sort of reflux condenser. The hot acid thus obtained is led through a bleaching apparatus which also serves as a cooler to reduce the temperature and avoid cracking the receiving vessel. This apparatus is illustrated in Fig. 5.

As previously described it consists of a number of glass

tubes constructed so that the acid flows successively through all the tubes and being thus exposed to the air which is carried along with it, the hyponitric acid is oxidized and at the same time the heat is absorbed by trickling cold water on the outside of the tubes in the usual manner. Furthermore, if the acid is above standard strength (specific gravity 1.42), as is generally the case when crude acid is made solely for redistilling, the strength may be reduced by adding a calculated quantity of distilled water while it is running through the cooler, which also removes the heat thus generated.

This distillation of sulphuric acid presents a more difficult problem than the other on account of the high temperature at which it boils. Glass retorts with very thin walls have generally been found the only thing suitable, although it is well known that porcelain vessels have been used in concentrating chamber acid by distilling off the water and bringing it up to a strength somewhat below complete concentration, a process which, of course, does not require a temperature as high as the distribution of the concentrated acid itself.

After experimenting for some time, a method for using porcelain retorts was devised and a continuously operating system of stills made of this ware is now being successfully used by the J. T. Baker Chemical Company. The stills or retorts are made comparatively small and hemispherical in shape, being about 8 inches in diameter across the bottom. On each side are tubular openings of suitable size so that the retorts can be connected together by passing the tubular of one retort into the tubular of the retort next to it. Instead of having the retorts on a level as in the other systems, they are laid on an incline as shown in Fig. 6, so that the acid overflows from one retort into the next below, the position of the outlets being such that the acid stands at the depth of about 2 inches in each retort. The joints are packed with asbestos to prevent the escape of vapors, and the upper part of the retorts are protected to prevent the radiation of heat.

The fire is located at the lower end of the furnace with a long inclined flue over which the retorts are laid and the waste heat utilized for bringing the acid up to the boiling point before it reaches the point where the distillation takes place. A number of retorts can be placed on one furnace, and from about half of them nearest the lower end concentrated acid will be obtained, the others giving acid containing more or less water. The crude acid is supplied in a steady stream and is regulated so that there is a constant overflow of tailings from the last retort.

The impurities in crude sulphuric acid are principally sulphate of lead and sulphate of iron, and if present in any great quantity will give trouble by forming incrustations on the bottom of the retorts and cause bumping and breakage, unless the retorts are cleaned out at regular intervals of four or five weeks' steady running.

The condensation of sulphuric acid vapors may be effected in glass tubes without using water to absorb the heat, provided the tubes are long enough, say, 7 feet long by 1 inch diameter. Owing to the high temperature of the vapors the strain on the glass is very great, but with a good quality of glass having very thin walls this method of condensation has proved quite successful in the past, notwithstanding that breakage was a frequent occurrence, particularly in cold weather. The condensation, however, was seldom complete and there was more or less escape of acid fumes from the ends of the tubes, while the temperature of the condensed acid was very little below the boiling point, so that the receiving vessels, which were necessarily made of glass, were frequently cracked. The constant escape of irritating fumes and the danger to the operator from handling the hot acid added to the difficulties which made the problem of condensation a serious one.

The introduction of fused silica ware had helped to solve this problem, for owing to its great resisting power to changes in temperature, it is possible to use silica tubes in place of glass and sprinkle them with water. This not only effects a complete condensation of vapors, but reduces the temperature of the distillate to a point at which it can be handled with perfect safety.

* * * * * * * * *

In the discussion which followed the reading of this paper Prof. Edward Hart spoke of his own work in this field. As to the glass flasks mentioned by Mr. Baker, he said that they found them very unsatisfactory since they broke frequently and required a great deal of coal. In consequence of this he (Prof. Hart) devised the hanging test-tubes (Fig. 2) and they found that one sixth of the coal formerly used was sufficient.

Prof. Hart thought that the apparatus of Mr. Baker, made of porcelain, would probably not be so economical of coal as the Hart apparatus with the hanging test-tubes. A patent for a modification of the hanging test-tubes has been applied for which is an improvement on the old form. In the old form the circulation in the tubes was very poor, so that sulphate of soda was apt to accumulate and finally break the tube; but this was obviated by the modification shown in Fig. 7, in which *A* is the acid receiver, *B* the hanging tubes, *J* a trough for the supply acid and *H* thistle tubes feeding the acid to the bottom of the hanging test-tubes. The object of the introduction in this way is obvious, since the fresh acid is fed to the bottom of the hanging tube and the strong residues containing the sulphate of soda are forced through *G*. In case of hydrochloric acid the *I* stoppers are made of rubber.

Kitchen-Middens as Ethnological Records*

By Harvey W. Shimer

As our present city waste dumps will give to the future paleontologist a pretty good conception of some phases of our material civilization, so the waste allowed to accumulate around the dwellings of early man give us a rude conception, at least, of his stage of development. Very early man, by a trait which inheritance has made comprehensible to us, threw the waste of food and clothing immediately outside his dwelling, there to accumulate. To such masses of débris the name kitchen-midden, literally kitchen refuse heap, has been applied. Since in many regions the food of early man was largely shell-fish, and these heaps of refuse would consits largely of shells, the name shell-mounds is also applied to them.

Kitchen-middens vary much in size, from a length of a foot to that of a mile or more and from a thickness of a fraction of an inch to that of 100 feet; from the few shells, bones, and charcoal, the refuse of a solitary hunter about his temporary camp, to the accumulations of a large village inhabiting the same locality through many centuries. Usually they have a diameter of 50 to 100 feet and a maximum thickness of 2 to 5 feet. In the permanent villages the dwelling came in time to occupy a depression in the accumulated mass. Besides being a repository for the waste of food, clothing and implements of war and hunting, they likewise were in many parts of the world used as burial places; just as many lowly tribes to-day bury their dead beneath their dwellings to keep them from disturbance and to have the protection of their spirits against enemies.

The distribution of kitchen-middens is world wide, they are found on all continents, North and South America, Europe, Asia, Africa, and Australia. They usually occur on the margins of bays or inland along streams and lakes. They frequently, in this country, occupy the same sites as the later white settlements and for the same reason, accessibility to water, food, and wood. The character of the middens naturally varies with the character of the food. Along the ocean margins the waste was marine shells and the bones of fish and mammals; inland it was fresh water shells and the remains of land animals, though the presence here of some marine forms indicates a system of traffic such as was practiced by the Indians upon the arrival of the whites.

The shell-mounds of the coasts of Maine and northeastern Massachusetts contain principally the remains of the clam, oyster, quahog, hen clam, scallop, deer, beaver, wild turkey, great auk, and many kinds of fish; with these occur fireplaces, charcoal, flint implements, and a little pottery. Many are the remains of animals now absent or very rare in these regions; among these are the oyster, quahog, wild turkey, and great auk. The presence in a midden at Ipswich, Mass., of human bones broken into short pieces as for the cook-in pot gives indication of cannibalism. This practice has been shown to have occurred at other places, as Florida, along the Atlantic coast.

Kitchen-middens are also very abundant in France, Denmark, Scotland, Italy, and Japan. In northern Italy they have received the name of terramara (bitter earth). They contain few or no shells but are phosphate deposits. These represent the accumulations beneath dwellings built on piles; and their slow accretion took place during the time when this region, expecially that lying between the River Po and the Apennines, was gradually changing from a condition of shallow lakes, or marshes with frequent inundations, to that of dry ground. These dwellings began apparently at the end of the Stone Age there and reached their greatest development about the fifteenth century B. C. The terramara deposits are apparently intermediate between the kitchen-middens proper (shell-mounds) of northern Europe and elsewhere and the lake dwellings of Switzerland; the different kind of accumulated waste indicating both the kind of dwelling used and food eaten.

The remains of shell-mounds (kitchen-middens proper) indicate that they were accumulated by people but slightly if at all acquainted with agriculture, whose subsistence depended mostly upon fishing and hunting, and who were largely in the Neolithic period of culture. Some mounds in the San Francisco Bay region must have been occupied for four or five thousand years at the least. This estimate is based largely upon the probable number of shell-fish, birds and mammals eaten by one individual and the approximate number of individuals in the village, reckoning each depressed area as the dwelling place of one family. Some of the mounds were occupied after the advent of the whites. The same is true on the Atlantic coast. In the Ipswich mound referred to above, it was only near the top of the mound that any objects of European make were found. Similarly on this coast the presence of rare or extinct species gives evidence of the lapse of many centuries since early man began here his primitive housekeeping. In the Americas the Indian is, at least in many cases, known to be the direct descendant of the kitchen-midden inhabitants.

*Abridged from *Science Conspectus.*

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

A Mathematical Nut to Crack for the New Year

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Let me propound the following seasonable problem: Find two quantities, barring fractions, the number and unity which multiplied together will make 1913.

SAMUEL W. BALCH.

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